TRANSCONA COMMUNITY AIR QUALITY MONITORING STUDY

LOCATION OF ENVIRONMENTAL AIR QUALITY SAMPLERS:
ÉCOLE REGENT PARK (July 20 to December 29, 2003)
BERNIE WOLFE SCHOOL (January 1 to April 10, 2004)
JOSEPH TERES SCHOOL (April 14 to July 15, 2004)
ÉCOLE MARGARET UNDERHILL (July 19 to October 25, 2004)
543 PANDORA AVENUE WEST (November 15, 2004 to March 8, 2005)

By Jean Van Dusen, M.A.Sc., P.Eng.
December 2006

Report No. 2006-01

Manitoba
spirited energy

Manitoba
Conservation

2007-01638/

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Conservation

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Van Dusen, J., 2006. *Transcona Community Air Quality Monitoring Study*. Manitoba Conservation, Air Quality Section, Report No. 2006-01, xiii+ 64

Abstract

Manitoba Conservation has completed a 21-month air quality monitoring program that assessed the outdoor community air quality in the Transcona area of Winnipeg. The objective of this monitoring program was to determine the general air quality in the Transcona area by comparing the air pollutant levels measured to existing air quality guidelines and to levels encountered in other areas of Winnipeg.

The monitoring program took place in two phases from July 2003 to March 2005. Air contaminants, such as those associated with industrial emissions, automobile exhaust and releases from various smaller industrial and commercial operations, were evaluated. During the first phase, air samples were collected for several months each on the rooftops of four local schools. During the second phase, air quality in the vicinity of a local industry (New Flyer Industries Inc.) was assessed.

The monitoring program measured levels of fine particulate matter (fine dust), 47 major constituents in that particulate matter, and 197 volatile organic compounds (VOCs) in the air in the Transcona community. Up to five 24-hour samples of particulate matter and VOCs were collected each week, resulting in over 70,000 data points being collected over the complete monitoring period.

Generally, the air quality in the Transcona area was found to be good with air quality guidelines rarely being exceeded. Air pollutant levels were generally very low, typically only a small fraction of the air quality guidelines and similar to the air quality found in other areas of Winnipeg.

VAN DUSEN, J. *Transcona Community Air Quality Monitoring Study*, Conservation Manitoba, Section de la qualité de l'air, rapport n° 2006-01, 2006, xiii-64 p.

Résumé

Conservation Manitoba a terminé un programme de surveillance de la qualité de l'air, d'une durée de 21 mois, qui permettait d'évaluer la qualité de l'air ambiant extérieur dans le quartier de Transcona à Winnipeg. L'objectif de ce programme de surveillance était de déterminer la qualité générale de l'air dans le quartier de Transcona en comparant les niveaux de polluants de l'air mesurés dans ce quartier avec ceux figurant dans les lignes directrices existantes en matière de qualité de l'air, et avec ceux que l'on retrouve dans d'autres quartiers de Winnipeg.

Le programme de surveillance de l'air a été exécuté en deux phases, de juillet 2003 à mars 2005. Les aérocontaminants, comme ceux liés aux émissions industrielles, aux émissions de gaz d'échappement et aux rejets provenant de diverses exploitations industrielles et commerciales plus petites, ont été évalués. Au cours de la première phase, des échantillons d'air ont été prélevés, pendant plusieurs mois, sur les toits de chacune des quatre écoles locales. Au cours de la seconde phase, on a procédé à l'évaluation de la qualité de l'air à proximité d'une entreprise de ce quartier (New Flyer Industries Inc.).

Dans le cadre du programme de surveillance, on a mesuré les niveaux de particules fines (poussière fine), de 47 constituants importants de ces particules et de 197 composés organiques volatils dans l'air du quartier de Transcona. Au moins cinq échantillons (prélevés sur une durée de 24 heures) de particules et de composés organiques volatils ont été recueillis chaque semaine, permettant d'amasser plus de 70 000 points de données au cours de la période entière de surveillance.

En général, la qualité de l'air à Transcona était bonne, les niveaux des lignes directrices étant rarement dépassés. Les niveaux des polluants de l'air étaient généralement très bas et ne constituaient habituellement qu'une faible partie des niveaux figurant dans les lignes directrices en matière de qualité de l'air. En outre, la qualité de l'air était semblable à celle que l'on retrouve dans d'autres quartiers de Winnipeg.

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List of Abbreviations

CAC	criteria air contaminant
CO	carbon monoxide
CO_2	carbon dioxide
E	east
EDXRF	energy dispersive X-ray fluorescence
g TEQ/yr	grams of dioxins/furans (as toxic equivalents) per year
GC/MS	gas chromatography/mass spectrometry
km/hr	kilometres per hour
n	number of matching samples
N	north
NO_x	nitrogen oxides
NPRI	National Pollutant Release Inventory
p	correlation coefficient
PM	particulate matter
PM_{10}	particulate matter 10 micrometer or smaller in diameter
$PM_{2.5}$	particulate matter 2.5 micrometer or smaller in diameter
PM_C	particulate matter between 2.5 and 10 micrometer in diameter
S	south
SO_x	sulphur oxides
TEOM	tapered element oscillating microbalance
TPM	total particulate matter
VOC	volatile organic compound
W	west
$\mu g/m^3$	micrograms per cubic meter
µm	micrometer

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Executive Summary

Questions had been raised with Manitoba Conservation about the effects that local industry located in Transcona and adjacent communities might be having on the air quality in the Transcona area[1]. While the effect on local air quality from any one industrial source may not be significant, the total emissions from multiple sources may be having a combined effect. Other local air pollution sources which have the potential to affect local air quality include motor vehicles, residential activities such as firewood combustion, and small commercial operations.

To address these questions, Manitoba Conservation undertook a two phase, 21-month ambient air quality monitoring study in the Transcona area. This study was the first comprehensive evaluation of air quality in the Transcona area to be undertaken, and it establishes a baseline for air quality in this community.

Phase I (July 2003 to October 2004) of this air quality monitoring study was designed to provide a perspective on the general air quality in the Transcona area due to all local sources rather than to assess the effect of any specific industry. Ambient air quality samples were taken over a period of several months using monitors located on the rooftops at each of four sites in the community (École Regent Park, Bernie Wolfe School, Joseph Teres School, and École Margaret Underhill). Each site was selected to be reasonably representative of typical Transcona air quality without being unduly influenced by any one specific local source. Moving the monitoring location from site to site provided a broader coverage of the Transcona community.

Manitoba Conservation undertook Phase II (November 2004 to March 2005) of this air quality study to assess the influence a specific local industrial source of emissions might be having on local air quality. Phase II consisted of a four month ambient air quality monitoring program sited at a location in close proximity to a specific Transcona industry (New Flyer Industries Inc.).

All Phase I and Phase II samples were analyzed by Environment Canada's Environmental Technology Centre for particulate matter ($PM_{2.5}$ and PM_c[2]), metals and other constituents in the dust, and volatile organic compounds (VOCs) such as solvents. Up to five samples a week of particulate matter (PM) and associated constituents and VOCs were collected.

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[1] Transcona is a community east of the downtown area of Winnipeg. This community is bounded by Lagimodiere Boulevard on the west, the CPR rail line and Gunn Road on the north, the Perimeter Highway, and the Red River Floodway on the east, and the CNR rail line, St. Boniface Road, Murdock Road and Dugald Road on the south.

[2] $PM_{2.5}$: particulate matter 2.5 µm or less in diameter
PM_c: coarse particulate matter 10 µm or less in diameter but larger than 2.5 µm in diameter
PM_{10}: particulate matter 10 µm or less in diameter, calculated by adding $PM_{2.5}$ and PM_c
These three size fractions are more likely to result in health effects than larger particles, because they can be inhaled.

The Phase I and Phase II data were assessed separately because of the different objectives of the two parts of this study.

During Phase I and Phase II of this monitoring study, 262 particulate matter and 297 VOC samples were collected. The particulate matter samples were analyzed for PM_{10}, $PM_{2.5}$ and 47 constituents, while the VOC samples were analyzed for 197 compounds. In total, over 70,800 pieces of data were collected.

Phase I Results

Phase I of this air quality study was designed to address questions about the effects that industry and other sources located in Transcona and adjacent communities might be having on the air quality in the area. The Phase I results indicated that air quality in Transcona was good and was quite similar to the air quality observed at other monitoring sites in Winnipeg.

During Phase I, there were no exceedances of Manitoba ambient air quality criteria for particulate matter (PM_{10} and $PM_{2.5}$) nor were there any exceedances of the available Ontario ambient air quality criteria for the specific constituents found in the particulate matter. Direct comparison of daily Transcona with downtown Winnipeg particulate matter concentrations was limited, because the data at the Transcona and downtown Winnipeg sites were collected using different monitoring equipment.

For VOCs, acrolein and dichloromethane each exceeded their ambient air quality criteria[3] once, but the local sources responsible for these exceedances could not be identified. For dichloromethane, however, the unusually high concentration coupled with the high winds that day would suggest a very localized source of the solvent was responsible for the exceedance.

Phase II Results

The air quality monitoring conducted in Phase II of this study indicated that air quality in close proximity to a local source of emissions in Transcona was similar to the air quality observed elsewhere in Winnipeg.

During Phase II, there were no exceedances of the Manitoba ambient air quality criteria for particulate matter (PM_{10} and $PM_{2.5}$) or of the Ontario ambient air quality criteria for constituents associated with the particulate matter. Particulate matter and constituents associated with the particulate matter were found in normal and acceptable concentrations in the Transcona area directly in the vicinity of a local source of emissions.

For VOCs, there were no exceedances of the Ontario air quality criteria for any of the individual VOCs analyzed in Phase II. For the small subset of specific VOCs that were of particular interest, the average and median concentrations appeared comparable at the five monitoring sites. The maximum levels of this subset of the VOCs varied considerably with no discernible trend among the Phase I and Phase II sites.

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[3] The VOC and element concentrations were assessed using available Ontario ambient air quality criteria (http://www.ene.gov.on.ca/envision/gp/2424e04.pdf).

Overall, based on this two-phase monitoring program, the air quality in the Transcona area was found to be good with air quality guidelines only being exceeded on two occasions. All other air pollutant levels were generally very low, typically only a small fraction of the air quality guidelines and similar to air quality found in other areas of Winnipeg.

TRANSCONA COMMUNITY
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1. Background

Questions had been raised with Manitoba Conservation about the effects that local industry located in Transcona and adjacent communities might be having on the air quality in the Transcona area. While any one industrial source may not be significant, the total emissions from multiple sources may be having a combined effect. Other local air pollution sources which have the potential to affect local air quality include motor vehicles, residential activities such as firewood combustion, and small commercial operations.

As a result of these questions, Manitoba Conservation undertook Phase I of this study (July 2003 to October 2004), a 15-month outdoor ambient air quality monitoring program in the Transcona area. The objective of this program was to determine the general air quality in the area due to all the local sources rather than to assess the influence of any specific industry. Phase II of the study (November 2004 to March 2005) consisted of a four-month ambient air quality monitoring program located near New Flyer Industries Inc.. The objective of Phase II was to assess the effect a local industrial source of emissions might be having on air quality. This study was the first comprehensive evaluation of air quality in the Transcona area that has ever been undertaken, and it establishes a baseline for air quality in the Transcona community.

During Phase I, air quality samples were taken over a period of several months at four sites in the community. During Phase II, air quality samples were taken over a period of four months at a site located near New Flyer Industries Inc.. Both Phase I and Phase II samples were analyzed by Environment Canada's Environmental Technology Centre for particulate matter ($PM_{2.5}$ and PM_C[4]), metals and other constituents in the dust, and volatile organic compounds (VOCs) such as solvents.

In total, 262 particulate matter and 297 VOC samples were collected. The particulate matter samples were analyzed for PM_C, $PM_{2.5}$ and 47 constituents[5]; the VOC samples were analyzed for 197 organic compounds[6].

The particulate matter and associated constituents were sampled using a Rupprecht & Patashnick Co. Inc. Dichotomous Partisol - Plus Model 2025 sequential air sampler. The Partisol is an automated particulate sampler that simultaneously collects 2 particle size ranges; these samples were collected on Teflon filters over a 24-hour midnight-to-midnight sampling period on a pre-defined sampling schedule. These filters were then weighed to determine the mass of particulate matter captured by the filter. The particulate matter constituents on the filters were analyzed using energy dispersive X-ray

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[4] $PM_{2.5}$: particulate matter 2.5 µm or less in diameter
PM_C: coarse particulate matter 10 µm or less in diameter but larger than 2.5 µm in diameter
PM_{10}: particulate matter 10 µm or less in diameter, calculated by adding $PM_{2.5}$ and PM_C
These size fractions are more likely to result in health effects than larger particles, because they can be inhaled.

[5] The specific elements analyzed for are listed in Table 4 and Appendix B.

[6] The specific organic compounds analyzed for are listed in Table 5 and Appendix C.

fluorescence (EDXRF)[7]. Up to five samples a week of particulate matter (PM) and associated constituents were taken.

For VOCs, 24-hour (midnight-to-midnight) ambient air samples were collected on a pre-defined sampling schedule, using specially conditioned and treated stainless steel canisters (Summa canisters)[8]. The canisters were filled using a Xontech Inc. Model 910A Programmable Canister Sampler and a Model 912 Multi-Canister Sampling Adapter. The contents of the Summa canisters were then analyzed for a range of gaseous air contaminants; the specific VOCs were identified using gas chromatography with a mass selective detector (GC-MSD)[9]. Up to five samples a week of VOCs were collected.

In addition, an R.M. Young Company Model 05305V wind monitor, used to collect wind speed and wind direction data, was set up at a City of Winnipeg facility at 1500 Plessis Road. Successful data collection started in January 2004, and this monitor collected hourly wind speed and direction data for the remainder of the monitoring program. Wind speed and wind direction data from the Winnipeg International Airport[10] were also retrieved for use in the assessment of the Transcona air quality. These data were obtained from the Environment Canada Canadian Climate Data web site.[11]

This report summarizes the results from the monitoring conducted on the roof top at the five monitoring locations in Transcona during both phases of this study.

Phase I:

- École Regent Park at 411 Moroz St. (July 20 to December 29, 2003)
- Bernie Wolfe School at 95 Bournais Drive (January 1 to April 10, 2004)
- Joseph Teres School at 131 Sanford Fleming Road (April 14 to July 15, 2004)
- École Margaret Underhill at 25 Regina Pl. (July 19 to October 25, 2004)

Phase II:

- 543 Pandora Avenue West (Warren's Corner Sports at corner of Pandora Avenue West and Bismarck Street) (November 15, 2004 to March 8, 2005)

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[7] In EDXRF, material is exposed to high energy X-rays. The material absorbs and then releases energy which is detected by an energy dispersive fluorescence detector or spectrometer. Environment Canada Environmental Technology Centre. *Multi-element Analysis of Ambient Aerosols Using Energy Dispersive X-ray Fluorescence Spectrometry*. Method No.: 6.09/2.0/M. September 8, 2006.

[8] A Summa canister is a stainless steel vessel in which the internal surfaces have been specially passivated using the "Summa process". This process uses an electro-polishing step, followed by chemical deactivation, to produce a surface that is very chemically inert.

[9] In GC-MSD, the gas chromatograph separates VOCs into individual compounds which are then identified and weighed using mass spectrometry. Environment Canada Environmental Technology Centre. *Determination of Volatile Organic Compounds (VOCs) in Ambient Air by Gas Chromatography /Mass Spectrometry (GC/MS)*. Method No: 1.02/2.4/M. May 11, 2006.

[10] Winnipeg International Airport: Latitude: 49° 55' N; Longitude: 97° 13' W; Elevation: 238.70 m Environment Canada Climate Station ID: 5023222; World Meteorological Organization ID: 71852; Transport Canada ID: YWG

[11] Environment Canada Canadian Climate Data: www.climate.weatheroffice.ec.gc.ca/climateData/canada_e.html

Schools were chosen for the monitoring locations in Phase I, because these sites were viewed to be representative of local air quality. As well, school buildings tend to have flat roofs and be surrounded by open playing fields. The monitors are then less likely to be affected by trees or other buildings that may disturb the air flow or remove pollutants from the air.

The Phase II monitoring location was chosen because it was in close proximity (*i.e.*, within 20 m) to New Flyer Industries Inc. located at 711 Kernaghan Avenue. This site also allowed unrestricted air flow to the monitors. A building on the site had a relatively flat roof on which it was possible to build a small platform to support the monitoring equipment.

II. Summary of Air Quality Monitoring Activities

1. Identification of Potential Air Pollutants in the Transcona Area

Transcona is a community in the east corner of Winnipeg with a 2001 census population of 30,255 and which covers an area of about 29 square kilometres. Transcona is bounded on the west by Lagimodiere Boulevard, on the north by the CPR rail line and Gunn Road, and on the east by the Perimeter Highway and the Red River Floodway. The southern boundary consists of the CNR rail line, St. Boniface Road, Murdock Road, and Dugald Road.

Many industries are located in Transcona and adjacent areas (*e.g.*, St. Boniface and Rural Municipality of Springfield). These industrial sources, as well as other non-industrial sources such as motor vehicles, commercial operations, and residential wood combustion, release air pollutants that may be affecting the air quality in the Transcona area. In order to identify the potential air pollutants that may be present in Transcona, different sources of air emissions information were reviewed.

The largest industrial sources in and around the Transcona area and their emissions were identified from the National Pollutant Release Inventory (NPRI)[12]; these sources are listed in Table 1 and their locations are shown in Figure 1. Air pollutants released from these sources ranged from inorganic chemicals (*e.g.*, ammonia, sulphuric acid) to volatile organic compounds (VOCs)[13] (*e.g.*, ethyl benzene, isobutyl alcohol, toluene) to metals (*e.g.*, copper, manganese, zinc). The specific NPRI emissions for the companies listed in Table 1 can be found in Appendix A.

Table 1. NPRI Sources in Transcona and Surrounding Areas (Year 2003)

Community	Industrial Facility	
Transcona	Border Chemical Company Ltd.	New Flyer Industries Inc.
	Canadian National Railway	Palliser Furniture Ltd.
	City of Winnipeg, Water and Waste Department	Plasti-Fab Ltd.
	Griffin Canada Inc.	Westland Steel Products Ltd.
	Kitchencraft of Canada Ltd.	
Kildonan	NorthStar/Fairmont Plating Ltd.	
St. Boniface	Champ Industries	Lafarge Canada Inc.
	Craftline Countertops	Landmark Feeds
	Custom Castings Ltd.	Maple Leaf Consumer Foods
	Falcon Machinery (1965) Ltd.	Phillips & Temro Industries Ltd.
	Frank Fair Industries Ltd.	PPG Phillips Industrial Coatings
	Frenntag Canada Inc.	Ridley Inc.
	Guertin Brothers Coating and Sealants Ltd.	Royal Canadian Mint
	IKO Industries Ltd.	Shell Canada Products
	Interprovincial Cooperative Ltd.	The Versacold Group
East St. Paul	Imperial Oil	Palliser Furniture Ltd.

[12] NPRI: Environment Canada's NPRI is a legislated, national, publicly accessible inventory of emission sources in Canada. All sources that manufacture, process or otherwise use more than a threshold quantity of one or more of a list of NPRI substances are required to report their emissions to the NPRI. NPRI does not assess the environmental impact (if any) of the releases. (http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm)

[13] Volatile Organic Compounds (VOCs): VOCs are a group of carbon-containing compounds that tend to have a high evaporation rate because of a high vapour pressure and/or a low boiling point and so can therefore be more readily released into the air.

In 2003, the individual air pollutants released in the highest quantities by industrial facilities in the Transcona area, according to NPRI data, included zinc (379 tonnes), toluene (208 tonnes), xylene (92 tonnes), styrene (44 tonnes), methyl ethyl ketone (37 tonnes), methanol (27 tonnes), n-butyl alcohol (23 tonnes), and n-hexane (23 tonnes). Many of the criteria air contaminants[14] (CACs) were released in higher quantities: volatile organic compounds (VOCs) (2,436 tonnes), sulphur dioxide (1,044 tonnes), PM_{10} (389 tonnes), total particulate matter (370 tonnes), carbon monoxide (330 tonnes), $PM_{2.5}$ (10 tonnes), and nitrogen oxides (7 tonnes).

Other emission information was obtained from the environmental impact assessments submitted as part of the *Environment Act* licence proposals received from major facilities that were environmentally licensed in recent years. Other proposed developments in the area were also reviewed for potential releases based on information in the U.S. Environmental Protection Agency (EPA) document, *Compilation of Air Pollutant Emission Factors (AP-42)*[15], as well as other data sources.

Based on all of the above information, as well as on a review of air quality complaints received from Transcona residents and compiled by the Regional Operations Division of Manitoba Conservation, a list of air pollutants potentially emitted in the Transcona area was developed and is provided in Table 2.

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[14] Criteria air contaminants are air pollutants, such as volatile organic compounds (VOCs), sulphur dioxide, PM_{10}, and others, that can affect human health and contribute to air pollution problems such as smog, acid rain, and visibility. These pollutants originate from a number of sources such as industrial facilities, fuel combustion, transportation, and paved and unpaved roads.

[15] U.S. Environmental Protection Agency (EPA). *Compilation of Air Pollutant Emission Factors (AP-42)*. (http://www.epa.gov/ttn/chief/ap42/index.html)

Figure 1. NPRI and Other Industrial Facilities in Transcona and the Surrounding Area

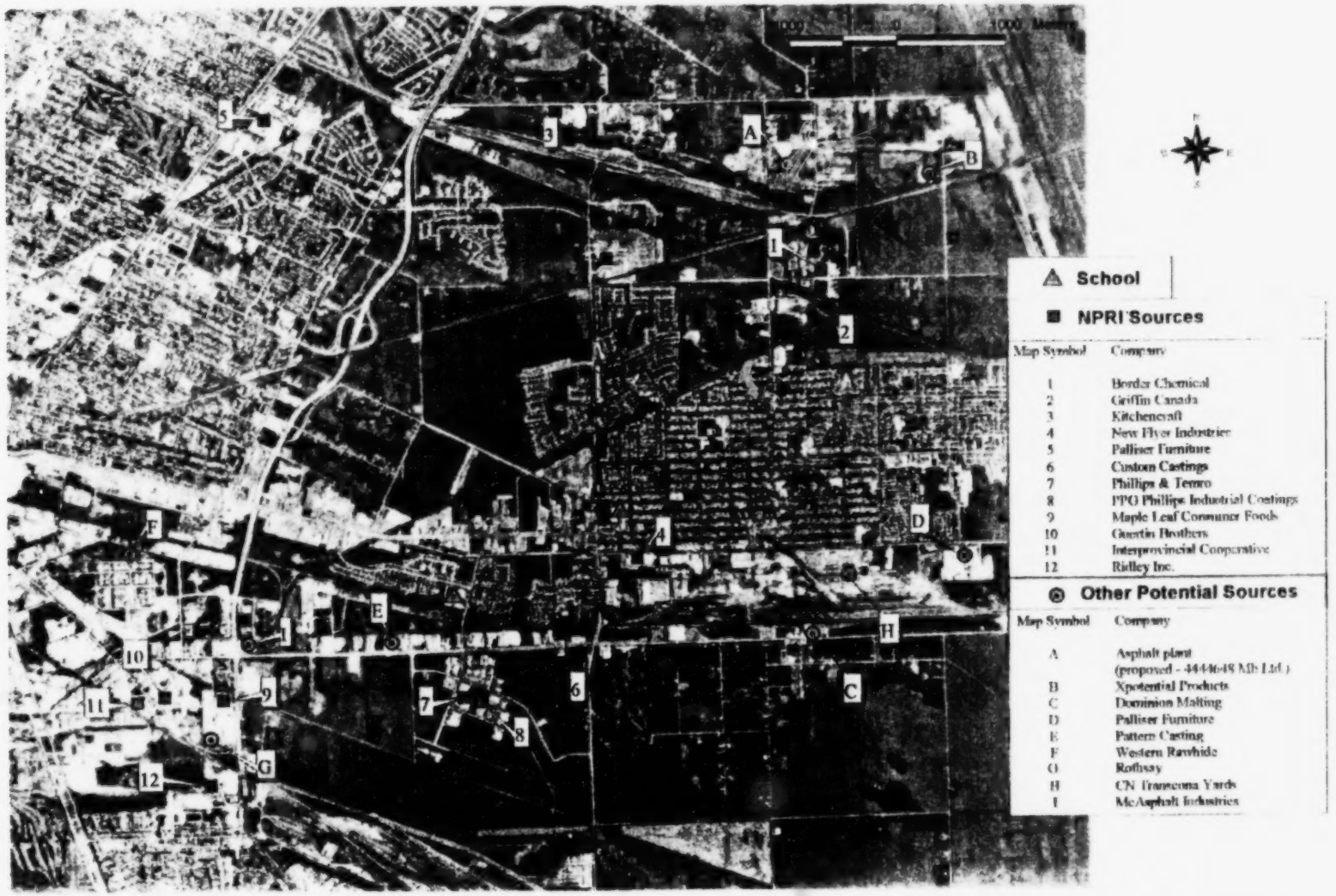


Table 2. Potential Air Pollutants Emitted in the Transcona Area

Pollutant Class	Potential Air Pollutants	
Criteria Air Contaminants (CAC's)	Carbon dioxide (CO_2) Carbon monoxide (CO) Nitrogen oxides (NO_x)	Particulate matter (total suspended particulate matter, PM_{10}) Sulphur oxides (SO_x)
Metals	Aluminum Antimony Chromium Copper	Lead Manganese Nickel Zinc
Volatile Organic Compounds (VOC's)	1,2,4-Trimethyl benzene * 2-Butoxyethanol Acetone Aliphatic hydrocarbons Aromatic naphtha Benzene * Butyl benzyl phthalate Diethanolamine Dimethylamine Dioxins/furans Ethyl acetate Ethanol (Ethyl alcohol) Ethyl benzene * Ethylene glycol Formaldehyde Hexachlorobenzene i-Butyl alcohol	Isobutyl acetate Isopropanol (Isopropyl alcohol) Methanol (Methyl alcohol) Methyl ethyl ketone Methyl isobutyl ketone Dichloromethane (Methylene chloride) Methylenebis(phenylisocyanate) Naphthalene * n-Butyl acetate n-butanol (n-Butyl alcohol) n-Hexane * Petroleum distillate Polycyclic aromatic hydrocarbons (PAH's) Propylene glycol monomethyl ether Styrene * Toluene * Xylene *
Inorganic chemicals	Ammonia Chloride Formic acid Hydrochloric acid	Nitrate ion Nitric acid Phosphoric acid Sulphuric acid

* These VOCs were also analyzed at the downtown Winnipeg air monitoring station

In addition to these larger sources, a multitude of smaller operations (*e.g.*, automotive body shops, metal recyclers, metal and plastic fabricators) are located in Transcona and the surrounding area. These operations and the quantities of air pollutants potentially released are typically much smaller than at the larger NPRI facilities. However, they may still be affecting local air quality because of their location and the number of these types of operations that exist in the area.

Examples of these smaller operations, the processes that typically occur in these types of facilities, and potential categories of emissions are shown in Table 3. The specific pollutants and the quantities released from these facilities are difficult to quantify and are not known. However, because of the similarity in the typical processes between these facilities and the larger NPRI industrial sources, they probably release many of the same pollutants as the NPRI sources, although in much smaller quantities.

Table 3. Typical Smaller Industries in the Transcona Area

Types of Industries	Typical Processes	Potential Emission Categories
Industrial and Commercial Metal Products Industries	Metal cutting, welding, solvent cleaning, painting	Particulate matter, metals, VOCs
Plastic Product Industries	Raw material handling, extrusion, cutting, painting	Particulate matter, VOCs
Non-metal Mineral Products Industries	Raw material handling, cutting, sanding	Particulate matter
Book Publishing Industry	Printing	VOCs
Wood Product Industry	Material handling, wood cutting, sanding, painting	Particulate matter, VOCs
Sawmill and Planing Mill Products Industry	Material handling, wood cutting, sanding	Particulate matter
Automotive	Sanding, solvent cleaning, painting	Particulate matter, VOCs
Scrap Metal Recyclers	Metal cutting	Particulate matter

2. Air Pollutants Monitored

The air pollutants that are potentially released in the Transcona area by local industrial sources fall into the following categories:

- Criteria air contaminants (nitrogen oxides, ozone, particulate matter – PM_{10} and $PM_{2.5}$)
- Metals
- Volatile organic compounds (VOCs)
- Inorganic chemicals

Nitrogen oxides and ozone are usually monitored using continuous analyzers that provide 1-hour average concentrations. These analyzers also require a data logger to collect and store the data which would then be downloaded to the Manitoba Conservation air quality data system computer. Because of the need for a dedicated structure to house these instruments, monitoring for nitrogen oxides and ozone was not undertaken. As well, data generally viewed to be representative of Winnipeg are available from other monitoring locations in Winnipeg. Other criteria air contaminants such as carbon monoxide and sulphur dioxide were not considered in this study as these two air contaminants are not typically elevated in Winnipeg.

Particulate matter (PM_{10} and $PM_{2.5}$) are typically monitored in the Manitoba air quality network using real-time, continuous, mass concentration instruments (Rupprecht & Patashnick Co. Inc. TEOM Series 1400a Ambient Particulate Monitor[16]) or multi-filter particulate samplers (Rupprecht & Patashnick Co. Inc. Dichotomous Partisol-Plus Model 2025 Sequential Air Sampler)[17] which take 24-hour samples on a midnight to midnight

[16] The TEOM (Tapered Element Oscillating Microbalance) is a true gravimetric instrument that draws ambient air through a filter at a constant flow rate, continuously weighing the filter and calculating near real-time mass concentrations.

[17] In a dichotomous Partisol sampler, the particles in the air stream entering the sampler are passed through a size-selective head which splits the sample into two streams. The first stream contains the fine particles ($PM_{2.5}$), while the second contains the coarse particles (*i.e.*, those particles 10 µm or less in diameter but larger than 2.5 µm in diameter).

basis. Since a TEOM analyzer would have required a more elaborate structure for protection and is not readily movable, a Partisol sampler was used in this study to collect 24-hour particulate samples on a Teflon filter. Also, the Partisol sampler allowed the samples to be analyzed using EDXRF to obtain concentrations of particulate matter constituents in the ambient environment. (The constituents for which the samples were analyzed are listed in Table 4 and Appendix B.)

Table 4. Constituents Analyzed in Transcona Particulate Matter Samples

Aluminum	Copper*	Neodymium	Sodium
Antimony	Gallium	Nickel*	Strontium
Arsenic	Germanium	Niobium	Sulphur
Barium	Indium	Palladium	Tellurium
Bromine	Iodine	Phosphorous*	Tin
Cadmium*	Iron	Potassium	Titanium
Calcium	Lanthanum	Praseodymium	Tungsten
Cerium	Lead*	Rubidium	Vanadium*
Cesium	Magnesium	Scandium	Yttrium
Chloride*	Manganese*	Selenium*	Zinc*
Chromium*	Mercury*	Silicon	Zirconium
Cobalt	Molybdenum	Silver	

*Particulate matter constituents identified as being manufactured, processed or otherwise used by NPRI industrial facilities within the Transcona area.

For VOCs, 24-hour passive samples were collected in this study using specially conditioned and treated stainless steel canisters (SUMMA canisters[18]). The canisters were filled using a Xontech Inc. Model 910A Programmable Canister Sampler and a Model 912 Multi-Canister Sampling Adapter. A controller, as well as a portable enclosure to house the canisters, was required to start the sample collection at midnight of the sampling day. The samples were subsequently analyzed at Environment Canada's specialized lab using GC-MSD. (A list of the VOCs analyzed is provided in Table 5 and Appendix C.)

Table 5. Volatile Organic Compounds (VOCs) Analyzed in Transcona Air Samples

1,1,1-Trichloroethane	2-Ethoxy-2-Methyl-Propane (ETBE)	Carbon tetrachloride	Isobutyl Acetate
1,1,2,2-Tetrachloroethane	2-Ethyl-1-Butene	Chlorobenzene	Isobutyl Alcohol *
1,1,2-Trichloroethane	2-Ethyl toluene	Chloroethane	iso-Butylbenzene
1,1-Dichloroethane	2-Methoxy-2-Methyl-Propane (MTBE)	Chloroform	Isopentane

[18] A Summa canister is a stainless steel vessel in which the internal surfaces have been specially passivated using the "Summa process". This process uses an electro-polishing step followed by chemical deactivation to produce a surface that is very chemically inert.

Table 5. Volatile Organic Compounds (VOCs) Analyzed in Transcona Air Samples (continued)

1,1-Dichloroethylene	2-Methyl Furan	Chloromethane	Isoprene
1,2,3-Trimethylbenzene	2-Methyl Propanal (Isobutyraldehyde)	cis-1,2-Dichloroethylene	Isopropyl Acetate
1,2,4-Trichlorobenzene *	2-Methyl-1-butene	cis-1,2-Dimethylcyclohexane	Isopropyl Alcohol *
1,2,4-Trimethylbenzene *	2-Methyl-1-Pentene	cis-1,3-Dichloropropene	iso-Propylbenzene
1,2-Dichlorobenzene	2-Methyl-2-butene	cis-1,3-Dimethylcyclohexane	m and p-Xylene *
1,2-Dichloroethane	2-Methyl-2-Pentene	cis-1,4 and trans-1,3-Dimethylcyclohexane	Methanol *
1,2-Dichloropropane	2-Methyl-2-Propenal (MAC)	cis-2-Butene	Methyl Ester, Acetic Acid (Methyl Acetate)
1,2-Diethylbenzene	2-Methyl Heptane	cis-2-Heptene	Methyl Isobutyl Ketone (MIK, MIBK) *
1,3,5-Trimethylbenzene	2-Methyl Hexane	cis-2-Hexene	Methylcyclohexane
1,3-Butadiene	2-Methyl Pentane	cis-2-Octene	Methylcyclopentane
1,3-Dichlorobenzene	2-Pentanone	cis-2-Pentene	MTBE (Tert-butyl methyl ether)
1,3-Diethylbenzene	2-Propenal (Acrolein)	cis-3-Heptene	Naphthalene
1,4-Dichlorobenzene	2-Propene Nitrile (Acrylonitrile)	cis-3-Methyl-2-pentene	n-Butylbenzene
1,4-Dichlorobutane	3,6-Dimethyl octane	cis-4-Methyl-2-pentene	Nonane
1,4-Diethylbenzene	3-Buten-2-one (Methyl vinyl ketone, MVK)	Cyclohexane	n-Propylbenzene
1-Butanol *	3-Ethyl toluene	Cyclohexanone	Octane
1-Butene and Isobutene	3-Methyl Butanal (Isovaleraldehyde)	Cyclohexene	o-Xylene *
1-Butyne	3-Methyl-1-Butene	Cyclopentane	p-Cymene
1-Decene	3-Methyl-1-Pentene	Cyclopentanone	Pentanal (Valeraldehyde)
1-Heptene	3-Methyl Heptane	Cyclopentene	Pentane
1-Hexene	3-Methyl Hexane	Decane	Propane
1-Methyl cyclohexene	3-Methyl Octane	delta-Limonene	Propylene
1-Methyl cyclopentene	3-Methyl Pentane	Dibromochloromethane	sec-Butylbenzene
1-Nonene	4-Ethyl Toluene	Dibromomethane	Styrene *
1-Octene	4-Methyl-1-Pentene	Dichloromethane (Methylene Chloride) *	tert-Butyl Benzene
1-Pentene	4-Methyl Heptane	Dodecane	Tetrachloroethene
1-Propanol (propyl alcohol)	4-Methyl Octane	Ethane	Tetrachloroethylene
1-Propyne	Acetaldehyde	Ethanol	Toluene *
1-Undecene	Acetone	Ethyl Acetate	trans-1,2-Dichloroethylene
2,2,3-Trimethyl Butane	Acetonitrile	Ethyl Benzene *	trans-1,2-Dimethylcyclohexane
2,2,4-Trimethyl Pentane	Acetylene	Ethyl Bromide	trans-1,3-Dichloropropene
2,2,5-Trimethyl Hexane	alpha-Pinene	Ethylene	trans-1,4-Dimethylcyclohexane
2,2-Dimethyl butane	Benzaldehyde	Ethylene Dibromide (EDB)	trans-2-Butene
2,2-Dimethyl hexane	Benzene	Ethylene Oxide	trans-2-Heptene
2,2-Dimethyl pentane	Benzyl chloride	Freon 11 (Trichlorofluoromethane)	trans-2-Hexene
2,2-Dimethyl propane	beta-Pinene	Freon 113 (1,1,2-trichloro-1,2,2-trifluoroethane)	trans-2-Octene
2,3,4-Trimethyl pentane	Bromochloromethane	Freon 114 (1,2-Dichloro-1,1,2,2-tetrafluoroethane)	trans-2-Pentene
2,3-Dimethyl butane	Bromodichloromethane	Freon 12 (Difluorodichloromethane)	trans-3-Heptene

Table 5. Volatile Organic Compounds (VOCs) Analyzed in Transcona Air Samples (continued)

2,3-Dimethyl pentane	Bromoform	Freon 22 (Chlorodifluoromethane)	trans-3-Methyl-2-pentene
2,4-Dimethyl hexane	Bromomethane	Heptane	trans-4-Methyl-2-pentene
2,4-Dimethyl pentane	Bromotrichloromethane	Hexachlorobutadiene	Trichloroethylene *
2,5-Dimethyl heptane	Butanal (Butylaldehyde)	Hexanal	Undecane
2,5-Dimethyl hexane	Butane	Hexane *	Vinylchloride
2-Butanol	Butyl Ester, Acetic Acid (Butyl Acetate)	Hexyl benzene	
2-Butanone (Methyl ethyl ketone, MEK) *	Camphene	Indane	
2-Butenal (Crotonaldehyde)	Carbon Disulfide	Isobutane	

*These substances were identified in Table A.1 as being released from NPRI facilities in Transcona, Kildonan, St. Boniface and East St. Paul.

Inorganic chemicals such as ammonia, chloride and formic acid are typically not included as part of an urban air quality monitoring program, nor are they expected to be elevated in urban areas. The analysis of inorganic chemicals was not included in this study because it would require the development of very specific monitoring methodologies or the leasing of highly specialized equipment.

The particulate size fractions PM_{10} and $PM_{2.5}$ are of most interest from a health perspective because these size fractions can be inhaled deep into the lungs. If larger particulate matter are inhaled, they are easily removed from the air stream in the nose or mouth and so do not reach the lungs. The PM_{10} size fraction tends to arise from physical processes such as wind erosion of soil surfaces or any operations where materials are handled or processed such as grinding or cutting. The $PM_{2.5}$ size fraction arises from combustion sources such as vehicle emissions and wood combustion; from industrial processes such as welding; or from photochemical or smog-forming reactions of certain chemicals in the atmosphere.

The individual VOC and particulate species potentially have human health and environmental effects; these effects vary depending both on the chemical nature of the VOC or particulate matter constituent and its concentration in the environment. The odour of the individual VOC species may also be noticeable in the environment in the vicinity of a source.

The dichotomous Partisol sampler and the Teflon filter cartridges are shown in Figure 2. The VOC sampler with the SUMMA canisters is shown in Figure 3.

Figure 2. Dichotomous Partisol Sampler with Teflon Filters

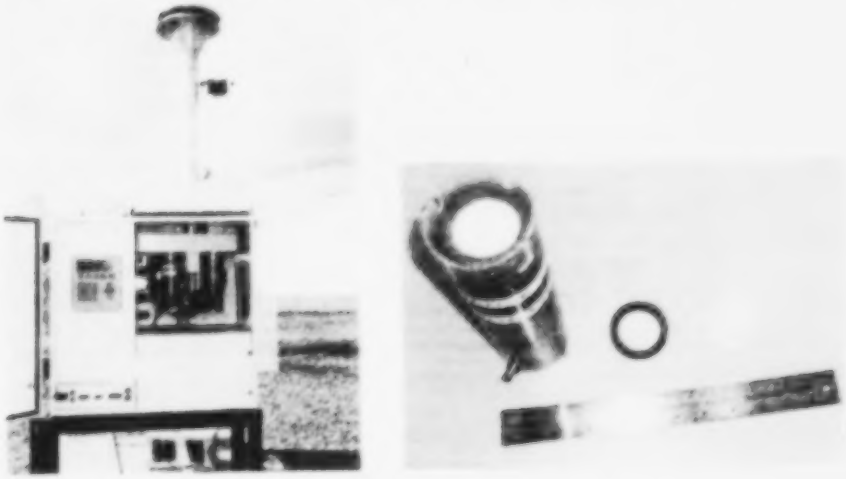
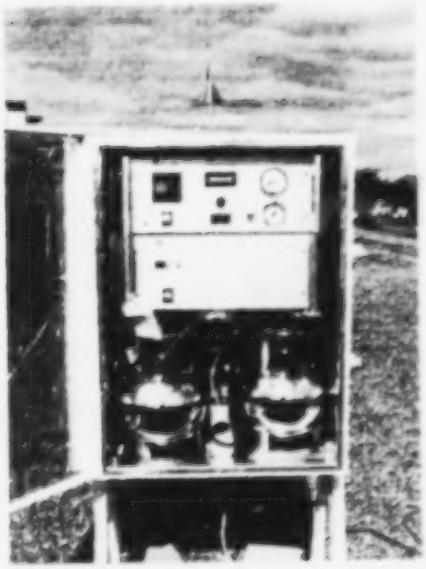


Figure 3. Volatile Organic Compound (VOC) Sampler Showing Summa Canisters



3. Monitoring Period

The Transcona area air quality monitoring study collected data over 21 months from July 2003 to March 2005, spending 3 to 6 months at each of the five monitoring locations. Relocation of the samplers provided the opportunity to assess air quality at more than one location in the Transcona area. A consequence of moving the monitoring location, however, was that it was not possible to assess any seasonal effects on air quality or to compare simultaneously air quality among the sites.

4. Sampling Schedule

In a typical long-term air quality monitoring program, air samples for the non-continuous monitoring of particulate matter and VOCs are taken every sixth day. However, in order to maximize the amount of data collected during this multi-site study, air quality samples were taken much more frequently. The sampling schedule was designed so that approximately two samples were taken every three days for a maximum of five samples a week of particulate matter and VOCs. These 24-hour samples were collected from midnight to midnight using automated timers following a pre-defined schedule.

5. Location of Monitoring Sites

Only one monitoring station was operated at a time over the duration of the study, but this station was sited at five different locations in the Transcona area in order to provide broader coverage of the community. The initial four sites which made up Phase I were selected to be reasonably representative of typical Transcona air quality without being unduly influenced by any one specific local source. The fifth site, Phase II of the study, was selected to provide ambient air quality data from a location in close proximity to a specific industrial source of emissions.

In locating the monitoring sites, basic requirements for siting were considered, including issues such as unrestricted air flow to the monitors and adequate separation distance from roads, in order to collect air quality samples representative of the region. Other considerations included the availability of electrical power for the instruments and site security.

As previously discussed, the four Phase I monitoring sites were located on the rooftops of selected schools in the Transcona area. The locations of these four schools are shown in Figure 4 and pictures of each individual school are shown in Figures 5 through 8. The Phase II monitoring site was located at 543 Pandora Avenue West (Warren's Corner Sports), within 20 m of New Flyer Industries Inc.. A picture of that location is shown in Figure 9.

Figure 4. Location of Phase I and Phase II Ambient Air Quality Monitoring Sites

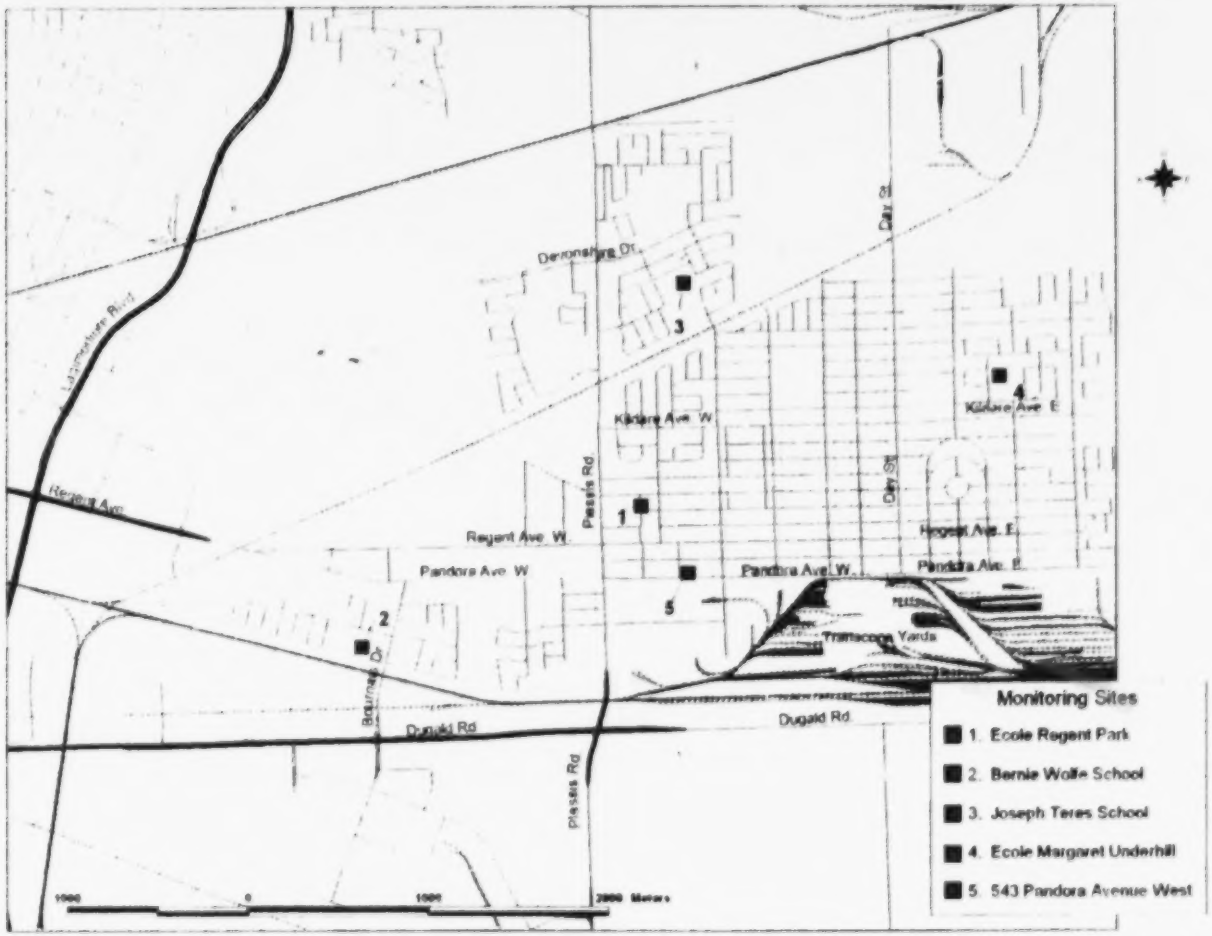


Figure 5. Phase I Site: Ecole Regent Park, 411 Moroz Street

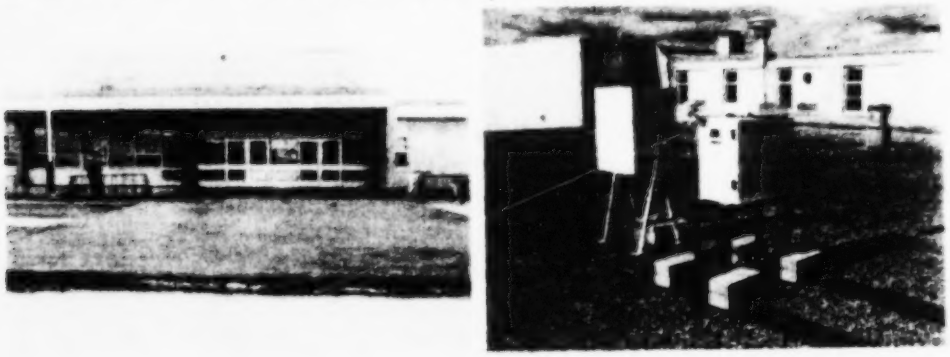


Figure 6. Phase I Site: Bernie Wolfe School, 95 Bournais Drive

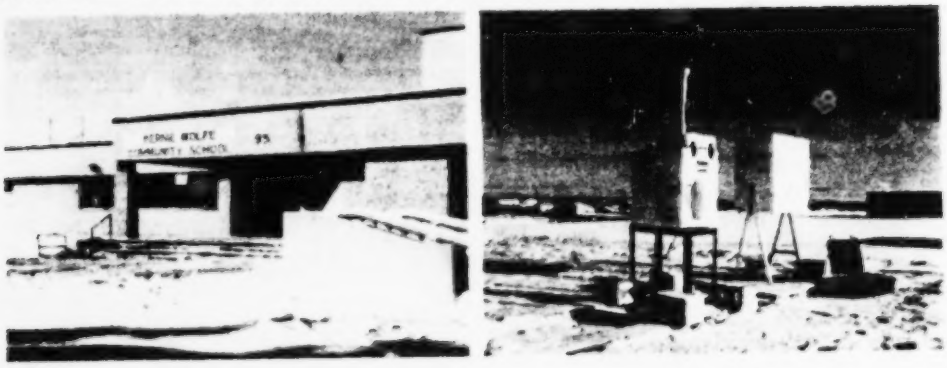


Figure 7. Phase I Site: Joseph Teres School, 131 Sanford Fleming Road

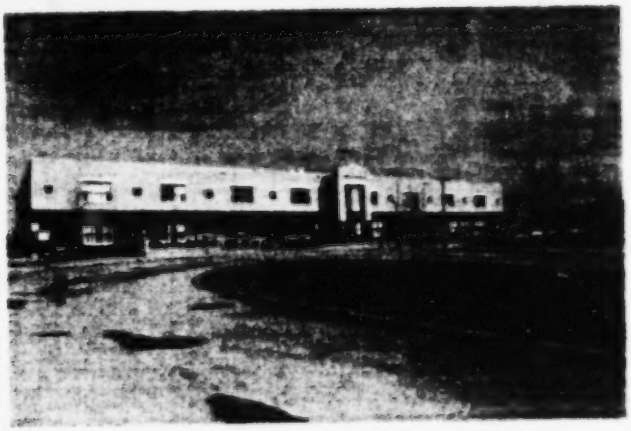


Figure 8. Phase I Site: École Margaret Underhill, 25 Regina Place

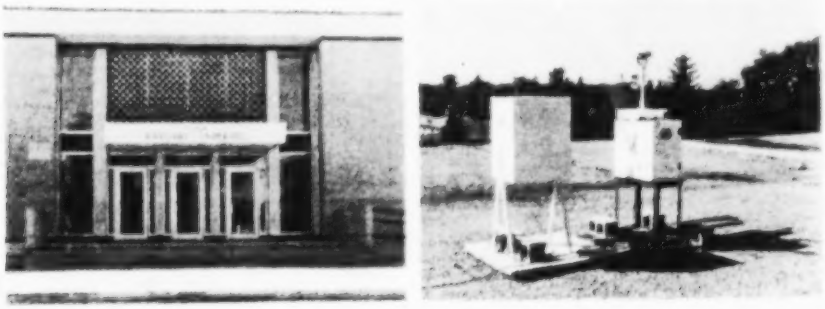
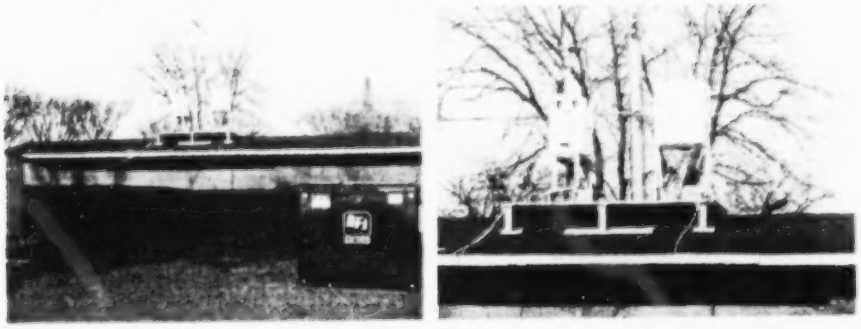


Figure 9. Phase II Site: 543 Pandora Avenue West



III. Assessment of Air Quality Monitoring Data

The Phase I and Phase II data have been assessed separately because of the different objectives of these two parts of the study. In order to provide a thorough assessment of the collected data, data from each Phase I monitoring site have been analysed individually and in conjunction with the other Phase I monitoring data. Because a single monitoring station was sequentially installed at five different locations, only limited comparisons of the data between the sites can be made. It was not possible to determine whether any differences identified are due to differences in local sources or to seasonal weather effects.

1. Transcona Air Quality Study: Phase I

A. École Regent Park (Sampling Period: July 20 to December 29, 2003)

1. Particulate Matter (PM_{10} and $PM_{2.5}$)

During the monitoring period undertaken at École Regent Park, located at 411 Moroz Street, fifty-seven 24-hour particulate matter samples were collected using a dichotomous Partisol sampler. Assessment of these samples showed that the maximums and averages for both PM_{10} and $PM_{2.5}$ were below their Manitoba 24-hour average, ambient air quality criteria of 50 $\mu g/m^3$ and 30 $\mu g/m^3$, respectively.

Table 6 summarizes the minimum, geometric mean and maximum values for PM_{10} and $PM_{2.5}$ at École Regent Park and at the other Winnipeg monitoring sites (*i.e.*, Ellens and Scotia)[19] during the same period of time, as well as correlation coefficients between the sites.[20] It should be noted that, despite the small amount of Ellens dichotomous data, its correlation with École Regent Park for PM_{10} and $PM_{2.5}$ is higher than the correlation between the École Regent Park and Ellens TEOM data.[21] The higher correlation implies that the particulate matter monitoring data obtained from the École Regent Park and Ellens dichotomous samplers are more similar than the data obtained from the École Regent Park dichotomous sampler and the Ellens TEOM.

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[19] The permanent air quality monitoring stations in downtown Winnipeg are located at 65 Ellen Street in the downtown area and at 299 Scotia Street in a residential area. At these two stations, various gaseous air pollutants (*e.g.*, carbon monoxide, oxides of nitrogen, and ozone) and particulate matter are measured. At the downtown station, other pollutants being measured include metals in the particulate matter and volatile organic compounds (VOCs).

[20] A correlation coefficient (p) indicates how much of the change in variable Y is related to a change in variable X. In this case, the correlation factor indicates how much a change in PM concentration in Transcona is related to a change in PM concentration at Ellens and at Scotia, respectively.
Strong: $p \geq 0.8$ Moderate: $0.5 < p < 0.8$ Weak: $p \leq 0.5$

[21] This lower correlation with the TEOM data may reflect the underestimation of PM_{10} and $PM_{2.5}$ by the TEOM which has been observed during the colder months. It is suspected that this is due to the heating of the TEOM which vaporizes any volatile particulate matter.

Table 6. École Regent Park Particulate Matter Statistics

Number of samples: 57

	PM_{10} (µg/m³)[1]				$PM_{2.5}$ (µg/m³)[1]			
	Minimum	Geometric Mean	Maximum	Correlation with École Regent Park data	Minimum	Geometric Mean	Maximum	Correlation with École Regent Park data
École Regent Park Dichotomous	3.04	14.70	45.09	-	1.45	6.76	20.10	-
Downtown Winnipeg (Ellens) Dichotomous	3.22	13.24	34.28	0.90 (strong) [n=21]	1.61	6.73	20.83	0.95 (strong) [n=21]
Downtown Winnipeg (Ellens) TEOM	1.93	14.42	57.50	0.84 (strong) [n=57]	0.29	3.67	12.43	0.71 (moderate) [n=57]
Winnipeg Residential Site (Scotia) TEOM	-	-	-	-	0.73	4.16	12.58	0.73 (moderate) [n=57]

[1] Ambient air quality criteria (24-hour average): PM_{10}: 50 µg/m³ $PM_{2.5}$: 30 µg/m³

n: number of matching samples

Figures 10 and 11 are plots of the 24-hour average concentrations for PM_{10} and $PM_{2.5}$ at École Regent Park and the other Winnipeg monitoring sites. These graphs show that particulate matter concentrations followed similar day-to-day trends in Transcona and at other Winnipeg sites.

Although it appears that $PM_{2.5}$ concentrations at École Regent Park were consistently higher than the other Winnipeg values, the continuous downtown and residential Winnipeg data are from the Ellens and Scotia TEOM analyzers and the difference is likely due to the use of different instruments. Figures 10 and 11 do show, however, that the agreement between the two types of samplers (TEOM and Partisol) was better during the warmer months.

The less frequent Ellens dichotomous data are much closer in value to the École Regent Park data. PM_{10} concentrations at École Regent Park were higher than downtown Winnipeg TEOM concentrations about half of the time, but were similar to downtown dichotomous concentrations. As previously stated and as shown in Table 6, the correlations between École Regent Park data and Ellens dichotomous data for PM_{10} and $PM_{2.5}$ were strong, at values of 0.90 and 0.95, respectively, implying a strong relationship between the data .

Figure 10. 24-hour Average PM_{10} Concentrations at École Regent Park and Downtown Winnipeg Monitoring Sites

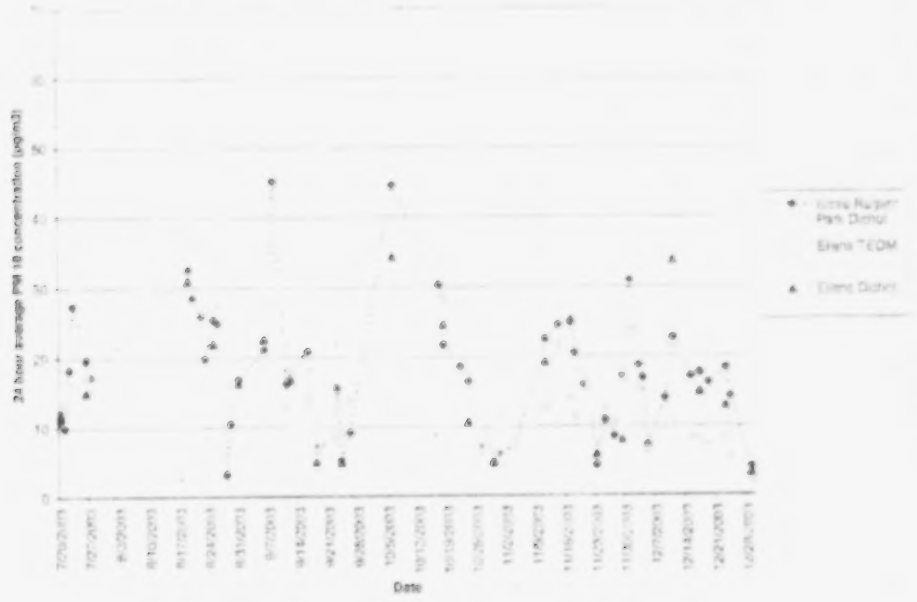
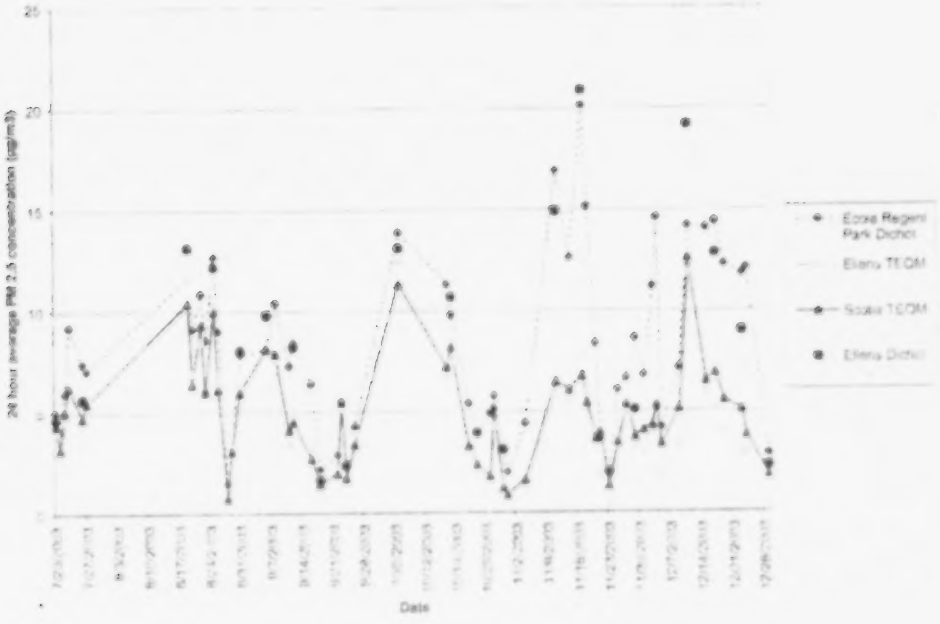


Figure 11. 24-hour Average $PM_{2.5}$ Concentrations at École Regent Park and Other Winnipeg Monitoring Sites



2. Metals and Other Constituents in Particulate Matter

Each of the 57 samples collected and analysed for particulate matter were also analysed for the 47 particulate matter constituents listed in Table 4. The minimum, maximum and average values for each constituent, along with the ambient air quality criteria[22], when available, are listed in Appendix D.

None of the particulate matter constituents had concentrations higher than the available ambient air quality criteria[23]. The maximum concentrations of most of the constituents were less than 10% of their respective criterion. Of the 47 constituents analyzed, only silicon, chloride, and iron were more than 10% of their criteria in either the PM_{10} or $PM_{2.5}$ samples. Silicon and iron are common components of the earth's crustal material such as soil and can become windborne during windy conditions.

3. Volatile Organic Compounds

During the monitoring period undertaken at École Regent Park, 67 air samples were collected using specially treated SUMMA canisters. Each of these samples was subsequently analyzed for the 197 VOCs listed in Table 5. The VOCs included in the analysis are usually associated with vehicle emissions, urban smog or common commercial/industrial process emissions. They also included compounds identified as being potentially released in the Transcona area.

The minimum, maximum and average concentrations for each compound analysed can be found in Appendix E, along with related downtown Winnipeg statistics and ambient air quality criteria, when available. Only one compound, acrolein (2-propenal), was found to have a concentration exceeding its ambient air quality criterion of 23.3 $\mu g/m^3$. Acrolein exceeded its criterion on October 15, 2003. On this date, most of the wind (~92% of the time) was from the north-west quadrant, as shown in Figure 12, with the largest component of the wind being from the west (38% of the time). The average wind speed during this time period was 20 km/hr.

A specific cause for the elevated acrolein concentration could not be identified. Acrolein can be formed through the combustion of fossil fuels or biomass (*e.g.*, wood, crop residue, *etc.*). Other sources of atmospheric acrolein include motor vehicle exhaust, tobacco smoke and some pesticides. Industrially and commercially, acrolein is used in leather tanning, pharmaceutical production and photography. Acrolein is not manufactured in Canada but is imported as a component in some pesticides. None of the NPRI facilities in the Transcona area reported releases of acrolein during the duration of this monitoring program.

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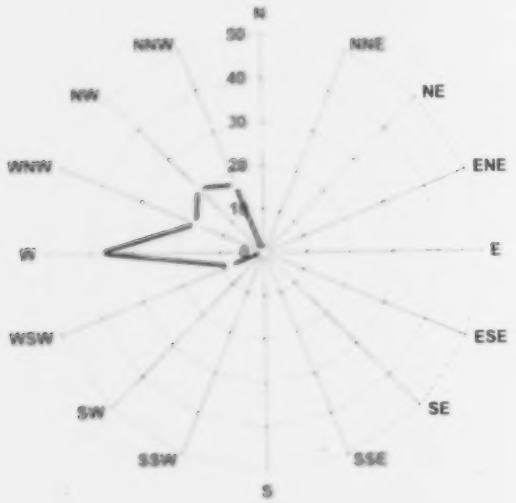
[22] The Ontario Ministry of Environment air quality criteria were used in the assessment of the Transcona air quality data.

[23] The concentration of those metals that were found to be below their detection limit was assigned a value equal to the detection limit divided by two.

Figure 12. École Regent Park Wind Rose for October 15, 2003



B. Bernie Wolfe School (Sampling Period: January 1 to April 10, 2004)

1. Particulate Matter (PM_{10} and $PM_{2.5}$)

During the monitoring period undertaken at Bernie Wolfe School, located at 95 Bournais Drive, fifty-five 24-hour particulate matter samples were collected using a dichotomous Partisol sampler. Assessment of these samples showed that the maximum and average values for both PM_{10} and $PM_{2.5}$ were below their respective Manitoba 24-hour average, ambient air quality criteria of 50 $\mu g/m^3$ and 30 $\mu g/m^3$.

Table 7 summarizes the minimum, geometric mean and maximum values for PM_{10} and $PM_{2.5}$ at Bernie Wolfe School and at other Winnipeg monitoring sites, as well as correlation coefficients between sites. Similar to the École Regent Park data, the correlations of the Ellens dichotomous data with Bernie Wolfe School data for PM_{10} and $PM_{2.5}$ are much higher than the correlation between Bernie Wolfe School and Ellens TEOM data. In general, the PM_{10} concentrations and statistics, including minimums, geometric means and maximums, were lower at Bernie Wolfe School than at the downtown Winnipeg monitoring sites. $PM_{2.5}$ concentrations and statistics were considerably higher than downtown and residential Winnipeg TEOM data, though similar to downtown Winnipeg dichotomous data.

Table 7. Bernie Wolfe School Particulate Matter Statistics
Number of samples: 55

	PM_{10} ($\mu g/m^3$)[1]				$PM_{2.5}$ ($\mu g/m^3$)[1]			
	Minimum	Geometric Mean	Maximum	Correlation with Bernie Wolfe School data	Minimum	Geometric Mean	Maximum	Correlation with Bernie Wolfe School data
Bernie Wolfe School Dichotomous	3.19	11.74	38.62	-	2.24	7.28	28.19	-
Downtown Winnipeg (Ellens) Dichotomous	5.34	12.48	31.63	0.97 (strong) [n=14]	3.51	7.96	26.55	0.97 (strong) [n=14]
Downtown Winnipeg (Ellens) TEOM	5.17	13.53	45.76	0.64 (moderate) [n=55]	1.25	3.62	13.79	0.82 (strong) [n=55]
Winnipeg Residential Site (Scotia) TEOM	-	-	-	-	1.55	3.91	12.03	0.86 (strong) [n=55]

[1] Ambient air quality criteria (24-hour average): PM_{10}: 50 $\mu g/m^3$ $PM_{2.5}$: 30 $\mu g/m^3$
n: number of matching samples

Figures 13 and 14 show plots of the 24-hour average concentrations for PM_{10} and $PM_{2.5}$ at the Bernie Wolfe School and other Winnipeg monitoring sites. These graphs show that particulate matter concentrations followed similar day-to-day trends in Transcona and at the other monitoring sites in Winnipeg.

Although it appears that $PM_{2.5}$ concentrations at Bernie Wolfe School were consistently higher than residential and downtown Winnipeg $PM_{2.5}$ values from the TEOM analyzers, the difference could be due to the use of different monitoring instruments. The less frequent Ellens dichotomous data are much closer in value to the Bernie Wolfe School data for both PM_{10} and $PM_{2.5}$. As previously stated and as shown in Table 7, the correlations between the Bernie Wolfe School and Ellens dichotomous data are strong, with a correlation coefficient of 0.97 for both PM_{10} and $PM_{2.5}$.

Figure 13. 24-hour Average PM_{10} Concentrations at Bernie Wolfe School and Downtown Winnipeg Monitoring Sites

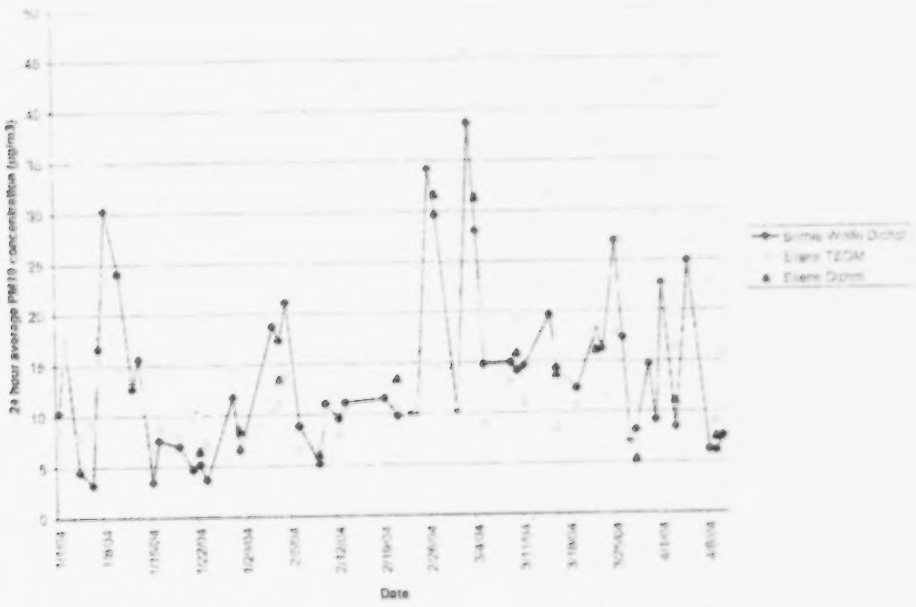
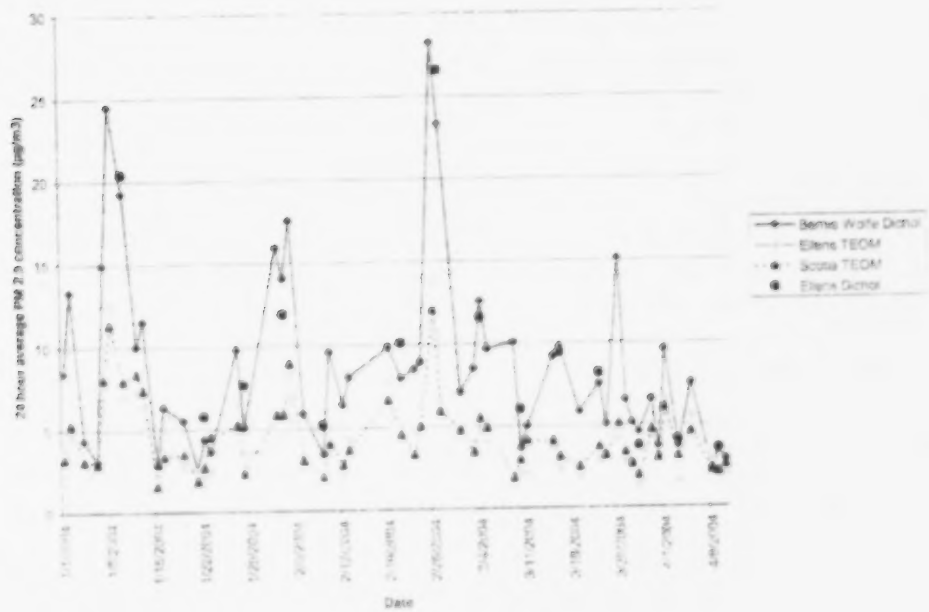


Figure 14. 24-hour Average $PM_{2.5}$ Concentrations at Bernie Wolfe School and Other Winnipeg Monitoring Sites



2. Metals and Other Constituents in Particulate Matter

Each of the 55 samples collected and analysed for particulate matter were also analysed for the 47 particulate matter constituents listed in Table 4. The minimum, maximum and average values for each metal, along with the ambient air quality criteria, when available, are listed in Appendix D.

None of the constituents had concentrations higher than the available ambient air quality criteria[24], and the maximum concentrations of most of the metals were less than 10% of their respective criteria. Of the 47 particulate matter constituents analyzed, only silicon, chloride, and iron were more than 10% of their criteria in either the PM_{10} or $PM_{2.5}$ samples. Silicon and iron are common components of crustal material such as soil and can become windborne during windy conditions.

3. Volatile Organic Compounds

During the monitoring period undertaken at Bernie Wolfe School, 58 air samples were collected using specially treated SUMMA canisters. Each of these samples was analysed for the 197 VOCs listed in Table 5. The minimum, maximum and average concentrations for each compound analysed can be found in Appendix E, along with related downtown Winnipeg statistics and ambient air quality criteria, when available. None of the VOC species was found to be in exceedance of its air quality criterion at Bernie Wolfe School.

C. *Joseph Teres School (Sampling Period: April 14 to July 15, 2004)*

1. Particulate Matter (PM_{10} and $PM_{2.5}$)

During the monitoring period undertaken at Joseph Teres School, located at 131 Sanford Fleming Road, forty-three 24-hour particulate matter samples were collected using a dichotomous Partisol sampler. Assessment of these samples showed that the maximum and average values for both PM_{10} and $PM_{2.5}$ were below their Manitoba 24-hour average, ambient air quality criteria of 50 $\mu g/m^3$ and 30 $\mu g/m^3$, respectively.

Table 8 summarizes the minimum, geometric mean and maximum values for PM_{10} and $PM_{2.5}$ at Joseph Teres School and the other Winnipeg monitoring sites, as well as correlation coefficients between sites. Contrary to the data collected at the previous two monitoring sites, the correlations between the Joseph Teres School and Ellens dichotomous data for PM_{10} and $PM_{2.5}$ were low, with respective values of 0.49 and 0.55. A low correlation implies that the particulate matter concentrations obtained from the Joseph Teres School and the Ellens dichotomous samplers were not similar.

In general, the PM_{10} concentrations and statistics, including average and maximum values, were lower at the Joseph Teres School than at the downtown Winnipeg monitoring site. $PM_{2.5}$ statistics for Joseph Teres School were higher than the other Winnipeg TEOM data, though similar to downtown Winnipeg dichotomous data.

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[24] The concentration of those metals that were found to be below their detection limit was assigned a value equal to the detection limit divided by two.

Table 8. Joseph Teres School Particulate Matter Statistics

Number of samples: 43

	PM_{10} ($\mu g/m^3$)[1]				$PM_{2.5}$ ($\mu g/m^3$)[1]			
	Minimum	Geometric Mean	Maximum	Correlation with Joseph Teres School data	Minimum	Geometric Mean	Maximum	Correlation with Joseph Teres School data
Joseph Teres School Dichotomous	2.75	11.40	35.06	~	1.66	4.65	12.02	~
Downtown Winnipeg (Ellens) Dichotomous	1.46	11.69	36.81	0.49 (weak) [n=11]	0.62	4.69	12.61	0.55 (moderate) [n=11]
Downtown Winnipeg (Ellens) TEOM	3.39	19.49	50.82	0.74 (moderate) [n=43]	0.92	3.43	9.53	0.89 (strong) [n=43]
Winnipeg Residential Site (Scotia) TEOM	~	~	~	~	1.05	3.36	10.00	0.86 (strong) [n=43]

[1] Ambient air quality criteria (24-hour average): PM_{10}: 50 $\mu g/m^3$ $PM_{2.5}$: 30 $\mu g/m^3$

n: number of matching samples

Figures 15 and 16 show plots of the 24-hour average concentrations for PM_{10} and $PM_{2.5}$ at Joseph Teres School and the other Winnipeg monitoring sites. On a day-to-day basis, particulate matter levels followed similar trends at the Joseph Teres School and the other Winnipeg monitoring sites. The concentrations of PM_{10} at Joseph Teres School were, in general, much lower than the corresponding concentrations at the downtown Winnipeg site. The $PM_{2.5}$ concentrations at Joseph Teres School appear to be higher than the $PM_{2.5}$ concentrations obtained by the TEOM analysers. However, as with the previous two monitoring sites, this difference could be due to the use of different monitoring equipment. Figures 15 and 16 indicate that the agreement between the two types of samplers (TEOM and Partisol) was better during the warmer months.

Figure 15. 24-hour Average PM_{10} Concentrations at Joseph Teres School and Downtown Winnipeg Monitoring Sites

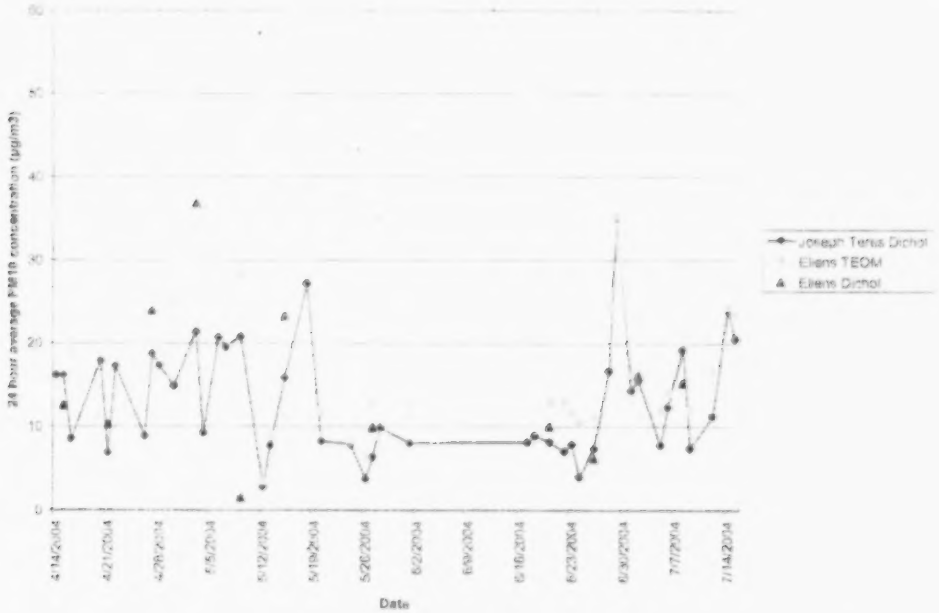
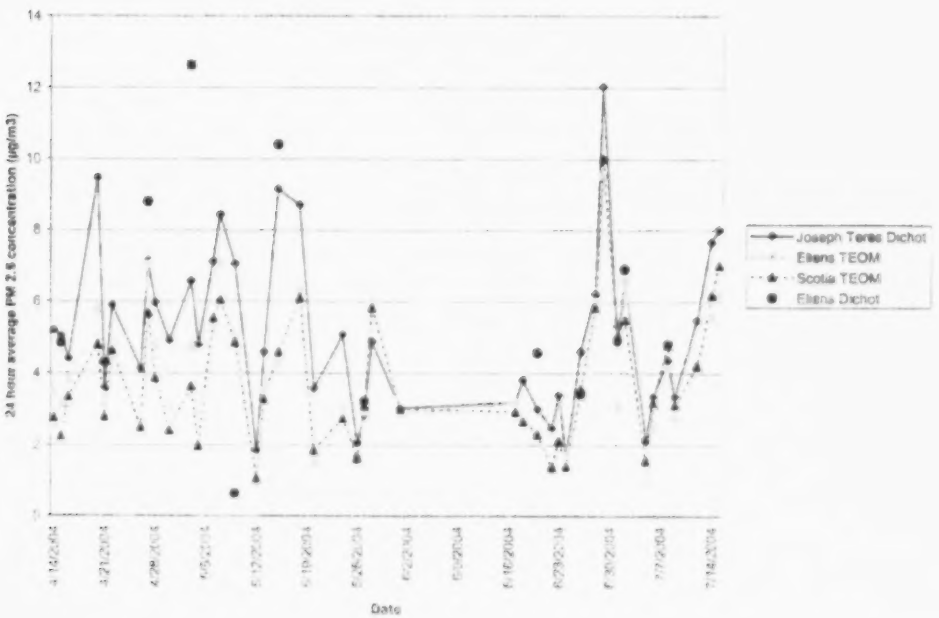


Figure 16. 24-hour Average $PM_{2.5}$ Concentrations at Joseph Teres School and Other Winnipeg Monitoring Sites



2. Metals and Other Constituents in Particulate Matter

The 43 samples collected and analysed for particulate matter were also analysed for the 47 constituents listed in Table 4. The minimum, maximum and average values for each particulate matter constituent, along with the ambient air quality criteria[25] when available, are listed in Appendix D.

None of the constituents had concentrations higher than the available ambient air quality criteria[26]. The maximum concentrations of most of the constituents were less than 10% of their respective criterion. Of the 47 particulate matter constituents analyzed, only silicon and iron were more than 10% of their criteria for the PM_{10} samples. Both of these are common components of crustal material such as soil and can become windborne during windy conditions.

3. Volatile Organic Compounds

During the monitoring period undertaken at Joseph Teres School, 54 air samples were collected using SUMMA canisters; each of these samples was analyzed for the 197 VOCs listed in Table 5. The minimum, maximum and average concentrations for each compound analysed can be found in Appendix E, along with related downtown Winnipeg statistics and ambient air quality criteria, when available. None of the VOC species was found to be in exceedance of its air quality criterion at the Joseph Teres School.

D. *École Margaret Underhill (Sampling Period: July 19 to October 25, 2004)*

1. Particulate Matter (PM_{10} and $PM_{2.5}$)

During the monitoring period undertaken at École Margaret Underhill, located at 25 Regina Place, fifty-five 24-hour particulate matter samples were collected using a dichotomous Partisol sampler. Assessment of these samples showed that the maximum and average values for both PM_{10} and $PM_{2.5}$ were below their respective Manitoba 24-hour average ambient air quality criteria of 50 $\mu g/m^3$ and 30 $\mu g/m^3$.

Table 9 summarizes the minimum, geometric mean and maximum values for PM_{10} and $PM_{2.5}$ at the École Margaret Underhill and other Winnipeg monitoring sites, as well as the correlation coefficients between the sites. The correlations between École Margaret Underhill and Ellens dichotomous data for PM_{10} and $PM_{2.5}$ were strong, similar to the correlations found for École Regent Park and Bernie Wolfe School. However, unlike the correlations between the first two monitoring sites and the other Winnipeg TEOM data, those at École Margaret Underhill were high for both PM_{10} and $PM_{2.5}$.

In general, the PM_{10} concentrations and statistics, including minimum, geometric mean and maximum values, were lower at École Margaret Underhill than at the downtown Winnipeg monitoring site. $PM_{2.5}$ concentrations and statistics were higher at École

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[25] The Ontario Ministry of Environment air quality criteria were used in the assessment of the Transcona air quality data.

[26] The concentration of those metals that were found to be below their detection limit was assigned a value equal to the detection limit divided by two.

Margaret Underhill than at the other Winnipeg TEOM sites, but were lower than at the downtown Winnipeg dichotomous site.

Table 9. École Margaret Underhill Particulate Matter Statistics
Number of samples: 55

	PM_{10} ($\mu g/m^3$)[1]				$PM_{2.5}$ ($\mu g/m^3$)[1]			
	Minimum	Geometric Mean	Maximum	Correlation with École Margaret Underhill data	Minimum	Geometric Mean	Maximum	Correlation with École Margaret Underhill data
École Margaret Underhill Dichotomous	3.60	12.16	40.77	~	1.64	4.87	18.49	~
Downtown Winnipeg (Ellens) Dichotomous	8.52	16.47	43.81	0.93 (strong) [n=15]	3.25	6.70	18.58	0.93 (strong) [n=15]
Downtown Winnipeg (Ellens) TEOM	1.15	13.68	55.32	0.89 (strong) [n=55]	0.46	3.42	16.87	0.95 (strong) [n=55]
Winnipeg Residential Site (Scotia) TEOM	~	~	~	~	0.48	3.73	14.73	0.92 (strong) [n=55]

[1] Ambient air quality criteria (24-hour average): PM_{10}: 50 $\mu g/m^3$ $PM_{2.5}$: 30 $\mu g/m^3$
n: number of matching samples

Figures 17 and 18 show plots of the 24-hour average concentrations for PM_{10} and $PM_{2.5}$ at the École Margaret Underhill and downtown Winnipeg monitoring sites. On a day-to-day basis, PM_{10} and $PM_{2.5}$ concentrations followed similar trends at École Margaret Underhill and the other Winnipeg monitoring sites.

Figure 17. 24-hour Average PM_{10} Concentrations at École Margaret Underhill and Downtown Winnipeg Monitoring Sites

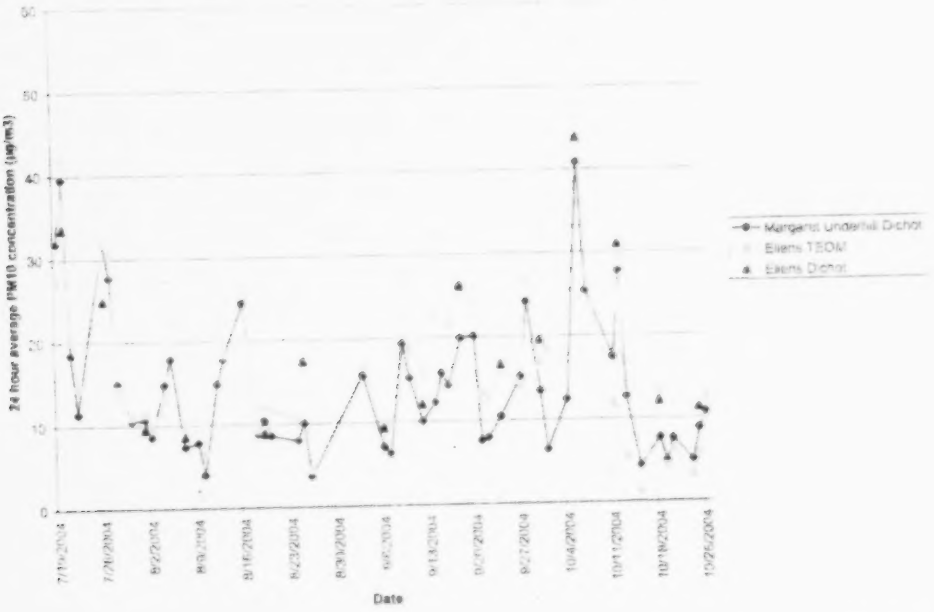
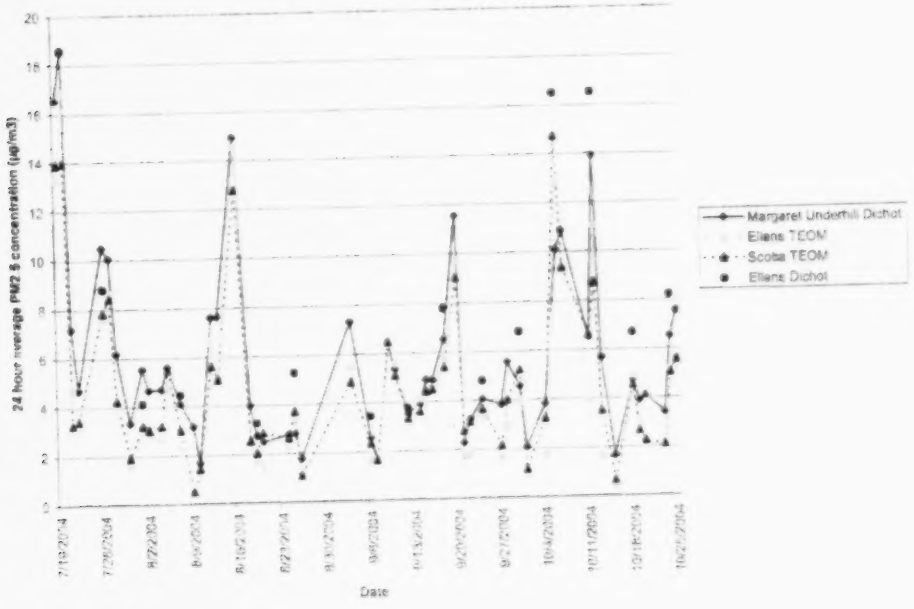


Figure 18. 24-hour Average $PM_{2.5}$ Concentrations at École Margaret Underhill and Other Winnipeg Monitoring Sites



2. Metals and Other Constituents in Particulate Matter

The 55 samples collected and analysed for particulate matter were also analysed for the 47 particulate matter constituents listed in Table 4. The minimum, maximum and average values for each constituent, along with the ambient air quality criteria[27], when available, are listed in Appendix D.

None of the constituents had concentrations higher than the available ambient air quality criteria[28]. The maximum concentrations of most of the constituents were less than 10% of their respective criterion. Of the 47 constituents analyzed, only silicon, iron and cobalt were more than 10% of their criteria for the PM_{10} samples. Silicon and iron are common components of crustal material such as soil and can become windborne during windy conditions.

3. Volatile Organic Compounds

During the monitoring period undertaken at École Margaret Underhill, 56 air samples were collected using SUMMA canisters and analyzed for the 197 VOCs listed in Table 5. The minimum, maximum and average concentrations for each compound analysed can be found in Appendix E, along with related downtown Winnipeg statistics and ambient air quality criteria, when available.

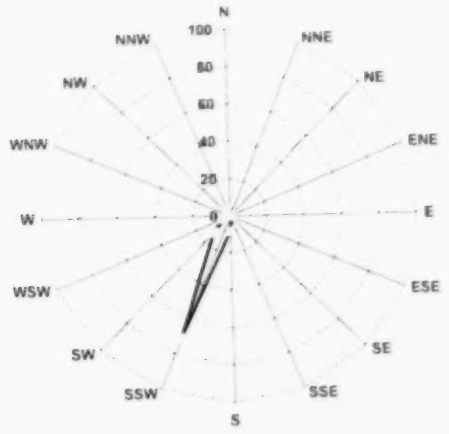
On Thursday October 7, 2004, dichloromethane was found in a concentration (1,866 $\mu g/m^3$) exceeding its corresponding ambient air quality criteria of 220 $\mu g/m^3$. This dichloromethane concentration far exceeded typical environmental levels for this compound. Dichloromethane, also known as methylene chloride, is commonly used as an industrial solvent and paint stripper. It may also be found in some aerosol and pesticide products.

Discussions with the laboratory service provider (Environment Canada) ruled out contamination of the VOC sample during the laboratory analysis. The custodial staff at École Margaret Underhill indicated that no solvents had been used at the school on that day; as well, dichloromethane was not identified as a component in their usual cleaning products. The school staff also indicated that any activity potentially involving heavy solvent usage, such as wax stripping of the floors, would have been conducted during the summer months rather than on a school day. The wind was predominantly from the south-south-west on October 7th with a high average wind speed of 25.7 km/hr, as seen in Figure 19. These factors and the high wind speed, which would tend to quickly dilute any air pollutant released in the environment, suggested that a local, nearby source of dichloromethane was responsible; however, the source could not be identified.

[27] The Ontario Ministry of Environment air quality criteria were used in the assessment of the Transcona air quality data.

[28] The concentration of those metals that were found to be below their detection limit was assigned a value equal to the detection limit divided by two.

Figure 19. École Margaret Underhill Wind Rose for October 7, 2004



E. *Summary of Transcona Phase I Monitoring Sites (Sampling Period: July 20, 2003 to October 25, 2004)*

In addition to considering each of the four monitoring sites individually, a summary has been prepared of the overall air quality in the Transcona area as represented by data from all four sites. Since the monitoring sites were moved periodically over the sampling period, any between-site comparisons are limited because of possible seasonal effects on the environmental concentrations.

1. Particulate Matter (PM_{10} and $PM_{2.5}$)

During the complete Transcona Phase I monitoring program undertaken sequentially at École Regent Park, Bernie Wolfe School, Joseph Teres School and École Margaret Underhill, two hundred and ten 24-hour particulate matter samples were collected using a dichotomous Partisol sampler. Assessment of these samples showed that all the daily average concentrations for both PM_{10} and $PM_{2.5}$ were below their Manitoba ambient air quality criteria (50 $\mu g/m^3$ and 30 $\mu g/m^3$, respectively).

Table 10 summarizes the minimum, geometric mean and maximum values for PM_{10} and $PM_{2.5}$ at all Phase I Transcona and other Winnipeg monitoring sites, as well as correlation coefficients between sites. For the entire Phase I monitoring period, as already noted, the correlations between the Transcona and Ellens dichotomous data for PM_{10} and $PM_{2.5}$ were substantially higher than the correlations between the Transcona dichotomous data and other Winnipeg TEOM data.

Table 10. Phase I Particulate Matter Statistics
Number of samples: 210

	PM_{10} ($\mu g/m^3$)[1]				$PM_{2.5}$ ($\mu g/m^3$)[1]			
	Minimum	Geometric Mean	Maximum	Correlation with Phase I data	Minimum	Geometric Mean	Maximum	Correlation with Phase I data
Transcona Phase I Dichotomous	2.75	12.52	45.09	–	1.45	5.86	28.19	–
Downtown Winnipeg (Ellens) Dichotomous	1.46	13.47	43.81	0.86 (strong) [n=61]	0.62	6.55	26.55	0.93 (strong) [n=61]
Downtown Winnipeg (Ellens) TEOM	1.15	14.88	57.50	0.74 (moderate) [n=210]	0.29	3.54	16.87	0.75 (moderate) [n=210]
Winnipeg Residential Site (Scotia) TEOM	–	–	–	–	0.48	3.81	14.73	0.77 (moderate) [n=210]

[1] Ambient air quality criteria (24-hour average): PM_{10}: 50 $\mu g/m^3$ $PM_{2.5}$: 30 $\mu g/m^3$
n: number of matching samples

Figures 20 and 21 show plots of the 24-hour average concentrations for PM_{10} and $PM_{2.5}$ at the Phase I and the other Winnipeg monitoring sites. PM_{10} and $PM_{2.5}$ concentrations followed similar day-to-day trends at Phase I monitoring sites and the other Winnipeg monitoring sites. In general, Phase I $PM_{2.5}$ concentrations were higher than the other Winnipeg TEOM concentrations. As previously discussed, this difference could be due to the use of different monitoring equipment. It should also be noted that although there is very little corresponding $PM_{2.5}$ downtown Winnipeg dichotomous data, the existing data appear to show concentrations similar to those observed in Transcona. Phase I PM_{10} concentrations were lower than downtown Winnipeg TEOM concentrations, though similar to downtown Winnipeg dichotomous concentrations.

Figure 20. 24-hour Average PM_{10} Concentrations at Phase I and Downtown Winnipeg Monitoring Sites

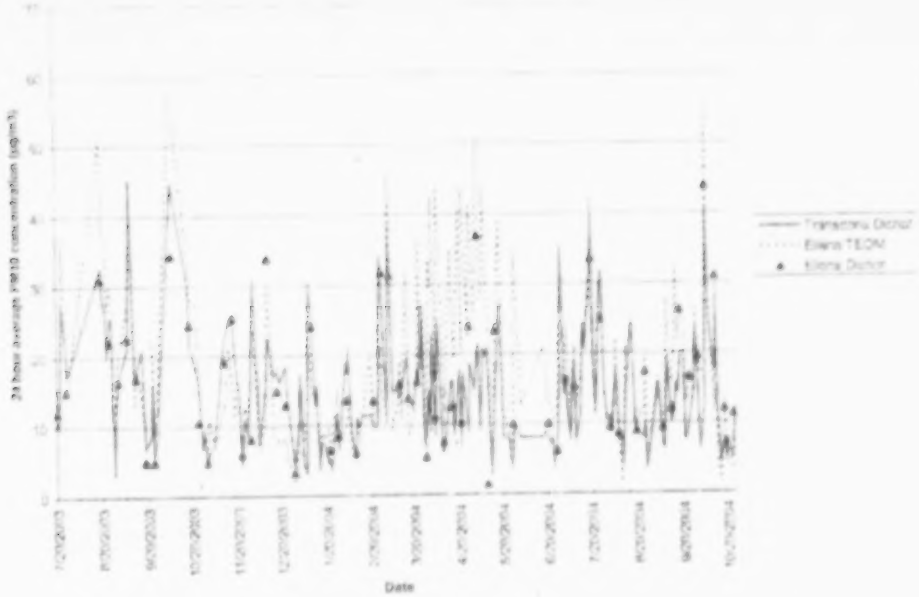
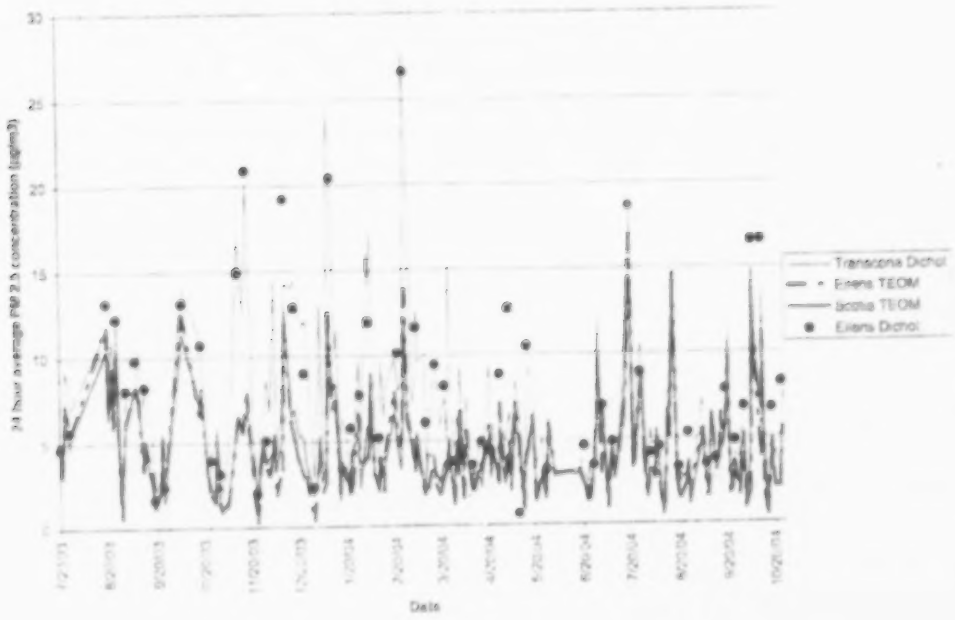


Figure 21. 24-hour Average $PM_{2.5}$ Concentrations at Phase I and Other Winnipeg Monitoring Sites



2. Metals and Other Constituents in Particulate Matter

The 210 samples collected and analysed for particulate matter during Phase I were also analysed for the 47 particulate matter constituents listed in Table 4. The minimum, maximum and average values for each constituent, along with the ambient air quality criteria[29], when available, are listed in Appendix D.

None of the constituents had concentrations higher than the available ambient air quality criterion at any of the Transcona Phase I sites; the maximum concentrations of most were less than 10% of their respective criteria[30]. Only silicon and iron were commonly more than 10% of their criteria, while chloride and cobalt occasionally exceeded 10% of their criteria. Silicon and iron are common components of crustal material such as soil and can become windborne during windy conditions.

3. Volatile Organic Compounds

During the Phase I monitoring period undertaken at four Transcona schools, 235 air samples were collected using SUMMA canisters and analyzed for the 197 VOCs listed in Table 5. The minimum, maximum and average concentrations for each compound analysed can be found in Appendix E, along with related downtown Winnipeg statistics and ambient air quality criteria, when available.

The only substances for which exceedances were found were acrolein (October 15, 2003) and dichloromethane (October 7, 2004). A specific cause for the elevated acrolein concentration could not be identified. The excessively high concentration of dichloromethane coupled with the high winds experienced that day would suggest that a very localized source of the solvent was responsible for the high concentration, although a source could not be identified.

2. Transcona Air Quality Study: Phase II:

A. Phase II Monitoring Site (Warren's Corner Sports) (Sampling Period: November 15, 2004 to March 8, 2005)

1. Particulate Matter (PM_{10} and $PM_{2.5}$)

During the monitoring period undertaken at the Phase II monitoring site, located at 543 Pandora Avenue West, fifty-two 24-hour particulate matter samples were collected using a dichotomous Partisol sampler. Assessment of these samples showed that the maximum and average values for both PM_{10} and $PM_{2.5}$ were below their Manitoba 24-hour average ambient air quality criteria of 50 $\mu g/m^3$ and 30 $\mu g/m^3$, respectively.

Table 11 summarizes the minimum, geometric mean and maximum values for PM_{10} and $PM_{2.5}$ at the Phase II monitoring site and the other Winnipeg monitoring sites, as well as

[29] The Ontario Ministry of Environment air quality criteria were used in the assessment of the Transcona air quality data.

[30] The concentration of those metals that were found to be below their detection limit was assigned a value equal to the detection limit divided by two.

correlation coefficients between sites. Also summarized were the PM_{10} and $PM_{2.5}$ concentrations for the combined Phase I study sites.

The correlations between the Phase II monitoring site and Ellens dichotomous data for PM_{10} and $PM_{2.5}$ were very high, with coefficients of 1.00 for both PM_{10} and $PM_{2.5}$. The correlations between the Phase II monitoring site and the other Winnipeg TEOM data for PM_{10} and $PM_{2.5}$ were significantly lower. In general, PM_{10} concentrations and statistics were lower at the Phase II monitoring site than at the downtown Winnipeg monitoring site and $PM_{2.5}$ concentrations and statistics were higher than other Winnipeg TEOM data, but similar to downtown Winnipeg dichotomous data.

In comparison with the particulate concentrations measured during Phase I (all sites combined) of the Transcona study, the average and maximum PM_{10} concentrations were somewhat higher at the other Transcona sites compared with the Phase II monitoring site. This may reflect the fact that the PM_{10} samples at the Phase II monitoring site were collected during the winter months (November to March) when the generation of PM_{10} through wind erosion of bare surfaces or vehicle entrainment of road dust would be minimized by the weather conditions. The average $PM_{2.5}$ concentration was higher at the Phase II monitoring site than during the Phase I study, but the highest $PM_{2.5}$ concentration was measured during the Phase I study.

Table 11. Phase II Particulate Matter Statistics

Number of samples: 52

	PM_{10} ($\mu g/m^3$)				$PM_{2.5}$ ($\mu g/m^3$)			
	Minimum	Geometric Mean	Maximum	Correlation with Phase II Site Data	Minimum	Geometric Mean	Maximum	Correlation with Phase II Site Data
Phase II Site Dichotomous	2.49	11.95	40.00	–	2.48	7.84	21.44	–
Downtown Winnipeg (Ellens) Dichotomous	5.55	11.66	45.71	1.00 (strong) [n=8]	3.41	7.86	26.40	1.00 (strong) [n=8]
Downtown Winnipeg (Ellens) TEOM	4.81	12.18	45.69	0.84 (strong) [n=52]	0.92	3.38	19.63	0.71 (moderate) [n=52]
Winnipeg Residential Site (Scotia) TEOM	–	–	–	–	1.75	4.38	17.23	0.70 (moderate) [n=52]
Transcona Phase I	2.75	12.52	45.09	–	1.45	5.86	28.19	–

†Ambient air quality criteria (24-hour average): PM_{10}: 50 $\mu g/m^3$ $PM_{2.5}$: 30 $\mu g/m^3$

n: number of matching samples

Figures 22 and 23 show plots of the 24-hour average concentrations for PM_{10} and $PM_{2.5}$ at the Phase II and downtown Winnipeg monitoring sites. In general, PM_{10} and $PM_{2.5}$ concentrations followed similar day-to-day trends at all of the monitoring sites. $PM_{2.5}$

concentrations at the Phase II monitoring site are consistently higher than the other Winnipeg TEOM concentrations. This difference may be due to the use of different monitoring equipment. The $PM_{2.5}$ data from the dichotomous sampler at the Phase II monitoring site are similar to the $PM_{2.5}$ data from the Ellens dichotomous monitor.

Figure 22. 24-hour Average PM_{10} Concentrations at the Phase II and Downtown Winnipeg Monitoring Sites

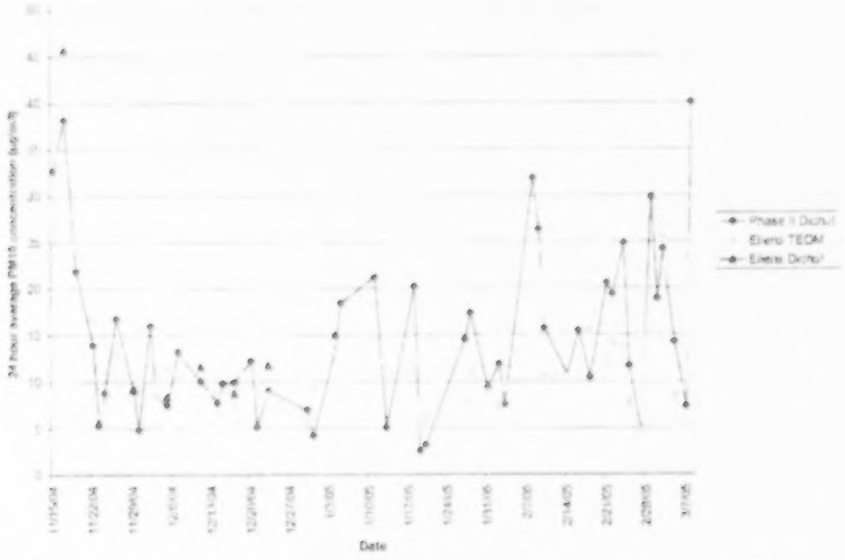
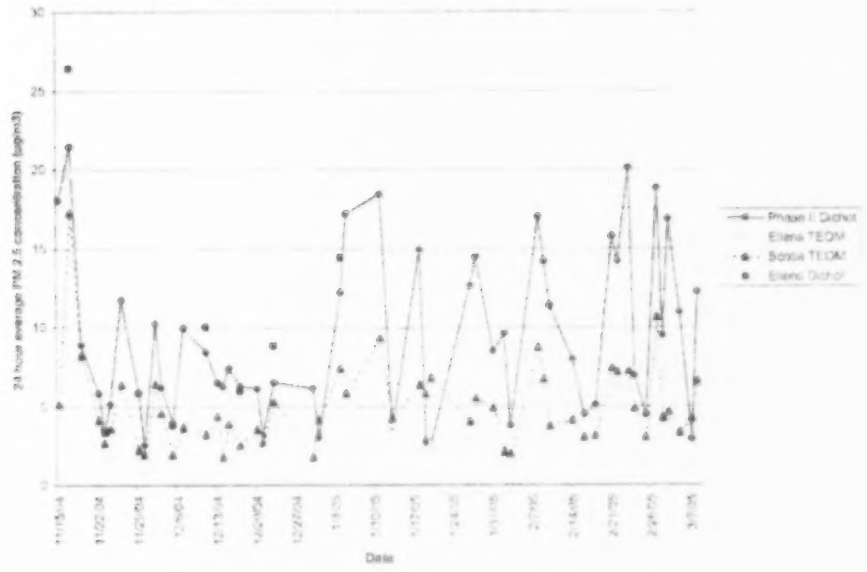


Figure 23. 24-hour Average $PM_{2.5}$ Concentrations at the Phase II and Other Winnipeg Monitoring Sites



2. Metals and Other Constituents in Particulate Matter

The 52 samples collected and analysed for particulate matter were also analysed for the 47 particulate matter constituents listed in Table 4. The minimum, maximum and average values for each constituent, along with the ambient air quality criteria[31], when available, are listed in Appendix D.

None of the constituents had concentrations higher than the available ambient air quality criteria[32]. The maximum concentrations of most of the constituents were less than 10% of their respective criterion. Of the 47 constituents analyzed, only silicon, iron, chloride and cobalt were more than 10% of their criteria for the PM_{10} samples. Silicon and iron are common components of crustal material such as soil and can become windborne during windy conditions.

3. Volatile Organic Compounds

During the monitoring period undertaken during Phase II, 62 air samples were collected using SUMMA canisters and analyzed for the 197 VOCs listed in Table 5. The minimum, maximum and average concentrations for each compound analysed can be found in Appendix E, along with related downtown Winnipeg statistics and ambient air quality criteria, when available. None of the VOC species was found to be in exceedance of its air quality criterion at the Phase II monitoring site.

4. Comparison with Air Quality Observations from Local Residents

In an attempt to correlate observations (especially of odour) to air measurements, air quality observation sheets were distributed to a few selected Transcona residents during Phase II of this monitoring study. The residents had previously expressed an interest in air quality or had lodged complaints about odours to Manitoba Conservation. A copy of the observation sheet is provided in Appendix F.

The observations submitted during the monitoring period at the Phase II site are summarized in Table 12.

Table 12. Air Quality Observations Submitted by Transcona Residents

Date	Time	Observations by Residents	Weather Observations	Top 4 VOCs[1,2]
1/27/2005	15:00	Odour	South wind at 33 km/hr; clear skies	***Acetone*** Methanol ***Ethanol*** ***Toluene***
	19:00	Odour	South wind at 41 km/hr; clear skies	
2/1/2005	15:00	Odour	South wind at 28 km/hr; mainly clear skies	No VOC sample collected

[31] The Ontario Ministry of Environment air quality criteria were used in the assessment of the Transcona air quality data.

[32] The concentration of those metals that were found to be below their detection limit was assigned a value equal to the detection limit divided by two.

Date	Time	Observations by Residents	Weather Observations	Top 4 VOCs[1,2]
2/2/2005	10:30	Odour	South-south-west (SSW) wind at 26 km/hr; mostly cloudy	***Methanol*** ***Propane*** ***Butyl acetate*** ***Toluene*** Date of 8th highest total VOC sum
2/9/2005	19:00	Heavy paint thinner smell	South wind at 17 km/hr; clear skies	***Ethanol*** Methanol ***Toluene*** ***Acetone***
2/9/2005	14:15	Odour	South wind at 15 km/hr; clear skies	
2/15/2005	19:16	Strong chemical smell, south wind	West-south-west (WSW) wind at 24 km/hr; mostly cloudy	Methanol ***Toluene*** Ethanol ***Propane***
2/23/2005	10:20	Strong chemical smell, south wind	SSW wind at 7 km/hr; fog	No VOC sample taken
3/2/2005	15:00	Odour	South wind at 17 km/hr; mainly clear skies	***Xylene*** ***Toluene*** ***Acetone*** Methanol
3/3/2005	14:50	Odour	SSW wind at 17 km/hr; cloudy skies	***Methanol*** ***Ethanol*** ***Acetone*** ***Toluene***
3/9/2005	10:15	Odour	South wind at 28 km/hr; mostly cloudy	***Methanol*** ***Acetone*** ***Ethanol*** ***Toluene***

[1] "Top 4 VOCs" for any date were those 4 VOCs with the highest measured concentrations on that date. The concentration of any VOCs shown in ***bold italics*** was higher on that day than the median concentration of that VOC over the sampling period at the Phase II site.

[2] Average odour detection thresholds[33] (*i.e.*, lowest concentration at which 50% of an odour panel could differentiate between the pollutant sample and a sample of odour-free air):
acetone: 147,000 µg/m^3 butyl acetate: 9 µg/m^3 ethanol: 736,000 µg/m^3
methanol: 4,500,000 µg/m^3 xylene: 87,000 µg/m^3
Except for butyl acetate, the most common VOC species identified in the samples had relatively high odour thresholds.

On those days in which odour was observed by local residents, the largest contributor to the total mass of VOCs tended to be toluene, methanol, ethanol and acetone. Because the different VOC species had substantially different odour thresholds, the VOC species with the highest concentrations were not necessarily responsible for the prevailing odour. For example, in footnote 2 of Table 12, the odour thresholds shown for the most prevalent VOC species ranged from 9 µg/m^3 for butyl acetate to 4,500,000 µg/m^3 for methanol. As

[33] American Industrial Hygiene Association, 1989. *Odor Thresholds for Chemicals with Established Occupational Health Standards*.

well, when dealing with mixtures of different substances, the resulting odour is not necessarily equal to the sum of the individual odours. Depending on the species, the individual odours may react with each other leading to either a reduced or enhanced overall odour.

The concentration of these VOCs over time is plotted for the Phase II site in Figure 24 along with those dates on which observations of odours had been made by the local residents. On those days for which odour had been noticed, the concentrations of these 4 VOCs were within the normal range for these species.

No observations of odour had been recorded on November 16, 2004 when higher concentrations had been recorded. On this date, the winds were primarily from the south (46% of the day) in the morning shifting to north-north-east (21% of the day) in the late afternoon and evening. The distribution of winds for November 16, 2004 are shown by the wind rose in Figure 25.

Figure 24. Top Four VOCs at Phase II Monitoring Site

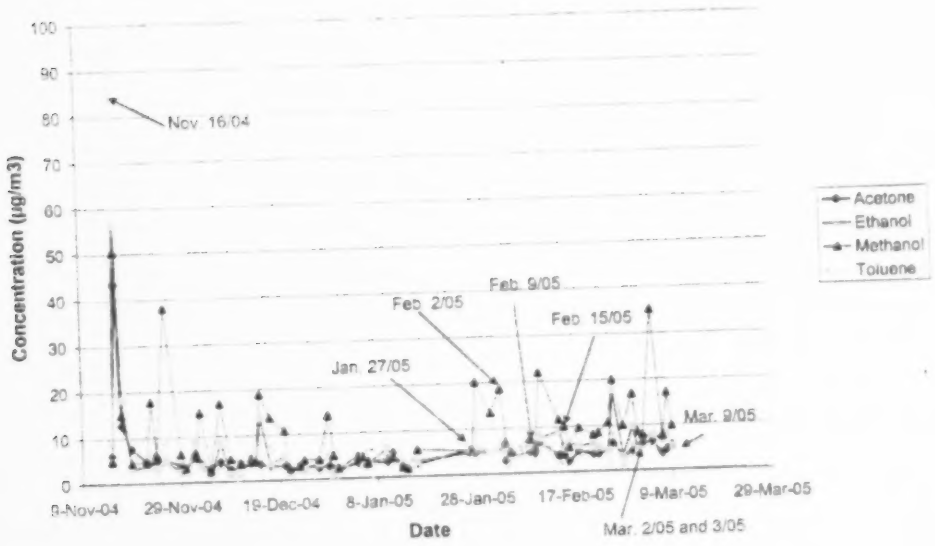
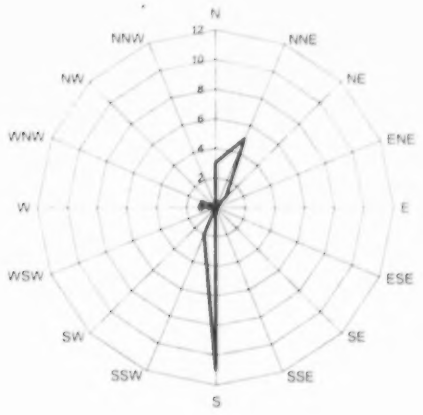


Figure 25. Phase II Wind Rose for November 16, 2004



3. Assessment of Individual Chemical Species: Phase I and Phase II

A. *Metals and Constituents in Particulate Matter*

The concentrations of nine specific metals for both the $PM_{2.5}$ and PM_{10} fractions were assessed for each of the Phase I and Phase II monitoring sites (zinc, titanium, aluminium, antimony, chromium, copper, lead, manganese, and nickel). Titanium and zinc are present in paint products used by New Flyer Industries Inc.. Zinc is a key component of the zinc primer, while titanium is found in paints as the white pigment titanium dioxide. The other seven metal species were among those listed in Table 2 as potential air pollutants emitted by sources in the Transcona area. Data from downtown Winnipeg were also included for the period 2003 to 2004.

1. Zinc and Titanium

The comparisons with downtown Winnipeg data for zinc and titanium are shown in Figures 26, 28, 30 and 32. The concentrations of these metals were also plotted with time over the entire sampling period in order to identify any high concentrations which may be influencing the results. (See Figures 27, 29, 31 and 33.)

The air quality criteria for zinc and titanium are both 120 $\mu g/m^3$. The highest zinc concentrations measured in Transcona were less than 0.15 $\mu g/m^3$, while the highest titanium concentrations were less than 0.14 $\mu g/m^3$. In all cases, the measured concentrations were at least 800 times lower than the air quality criteria.

For zinc in both the $PM_{2.5}$ and PM_{10} fractions, the geometric mean and median concentrations were similar at all five Transcona monitoring sites and at the downtown Winnipeg monitoring station. Both size fractions showed the highest zinc concentrations occurring at Joseph Teres School and École Margaret Underhill, while the maximum concentrations were lowest at the Phase II monitoring site. For over 79% of the samples,

the zinc in the $PM_{2.5}$ fraction was 50% or more of the zinc in the PM_{10} fraction. The median ratio of zinc in the $PM_{2.5}$ to PM_{10} fractions was 0.7. These results suggest that the zinc was predominantly in the $PM_{2.5}$ fraction, indicating that combustion sources may have contributed to the environmental zinc levels.

The plots of zinc concentration over the monitoring period (Figures 27 and 29) show higher than normal background levels occurring sporadically at Joseph Teres and École Margaret Underhill. Of the top six zinc concentrations measured, four occurred at École Margaret Underhill, while one occurred at each of the Joseph Teres and Bernie Wolfe schools. In all cases, the zinc concentrations were significantly less than the air quality guideline for zinc of 120 $\mu g/m^3$.

For titanium in the $PM_{2.5}$, the geometric mean concentrations were similar at all five Transcona monitoring sites and at the downtown Winnipeg monitoring station. The median concentrations at the Transcona monitoring sites were less than the detection limit for titanium, indicating that most of the samples did not have measurable titanium in the $PM_{2.5}$ size fraction. The geometric and median concentrations were similar at all five Transcona monitoring sites and at the downtown Winnipeg monitoring station. The highest titanium concentration occurred at École Margaret Underhill for the $PM_{2.5}$ size fraction.

In the PM_{10} size fraction, the geometric mean and median concentrations were similar at the monitoring stations located at the four schools in Transcona, at the Phase II monitoring site and at the downtown Winnipeg monitoring station. The highest titanium concentrations occurred at the Phase II site for the PM_{10} size fraction. The maximum concentrations were similar among the four schools and the downtown Winnipeg monitoring site.

For about 42% of the samples, the titanium in the $PM_{2.5}$ fraction was 50% or more of the zinc in the PM_{10} fraction. The median ratio of titanium in the $PM_{2.5}$ to PM_{10} fractions was 0.4. These results suggest that the titanium was predominantly in the PM_{10} fraction, indicating that combustion sources were less likely to be a significant contributor.

The plots of titanium concentration over the monitoring period (Figures 31 and 33) show higher than normal background levels occurring sporadically at the Phase II site. Of the top nine titanium concentrations measured, six occurred at the Phase II site, while one occurred at École Margaret Underhill and two occurred at École Regent Park. In all cases, the titanium concentrations were significantly less than the air quality guideline for titanium of 120 $\mu g/m^3$.

Figure 26. Phase I and Phase II Comparison of Zinc in $PM_{2.5}$ Concentrations

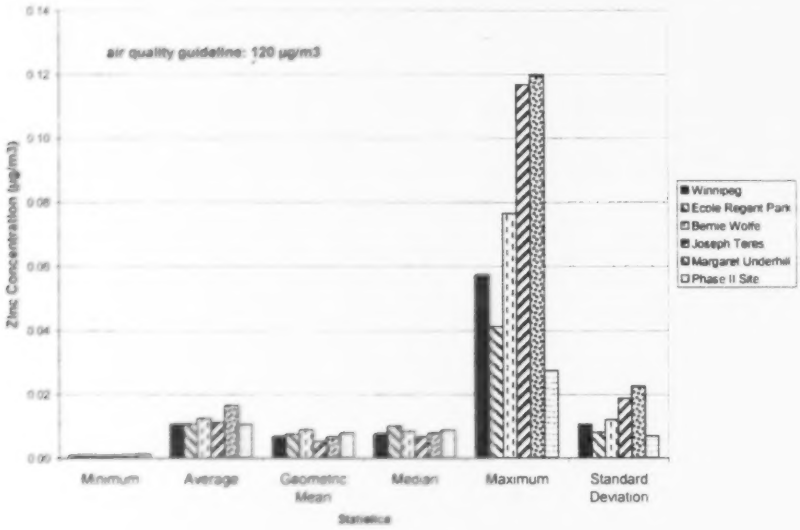


Figure 27. Phase I and Phase II Zinc in $PM_{2.5}$ Concentrations

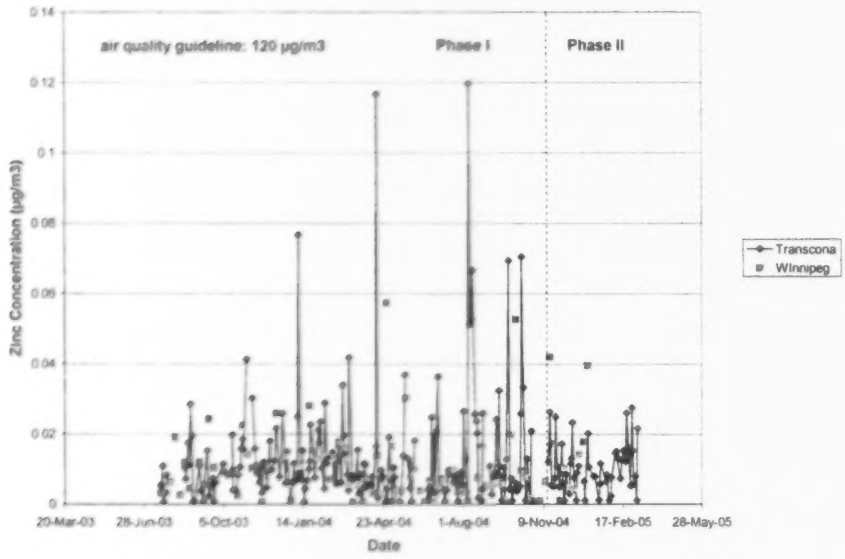


Figure 28. Phase I and Phase II Comparison of Zinc in PM_{10} Concentrations

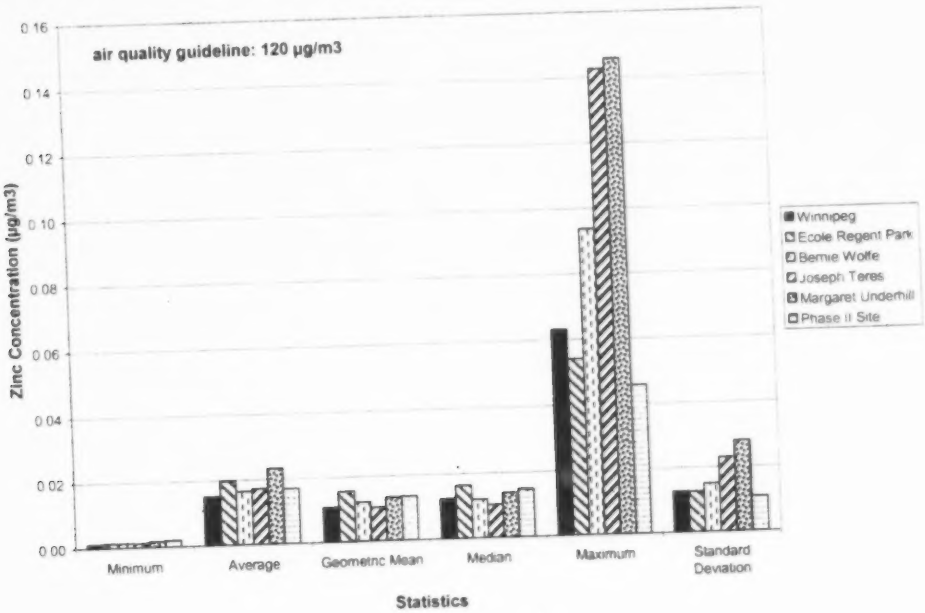


Figure 29. Phase I and Phase II Zinc in PM_{10} Concentrations

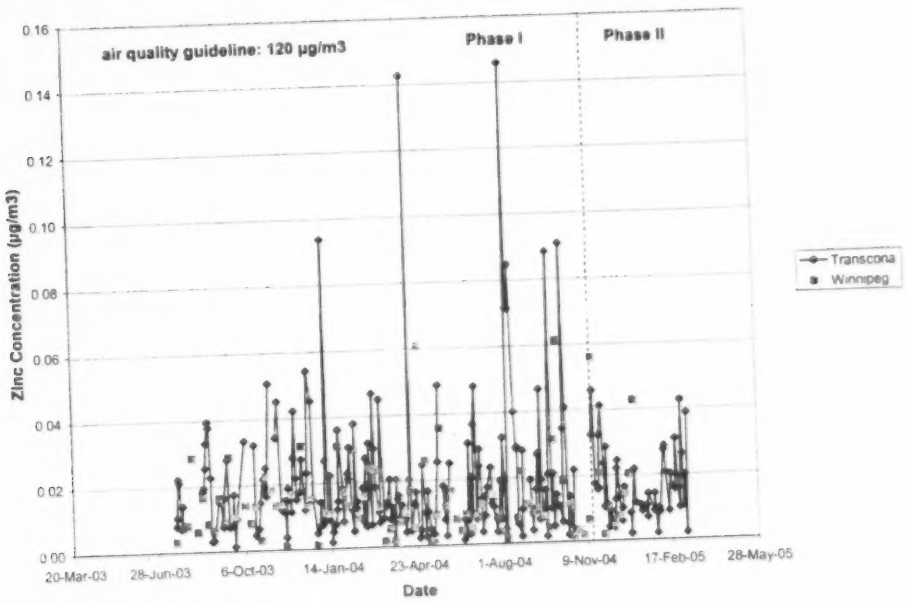


Figure 30. Phase I and Phase II Comparison of Titanium in $PM_{2.5}$ Concentrations

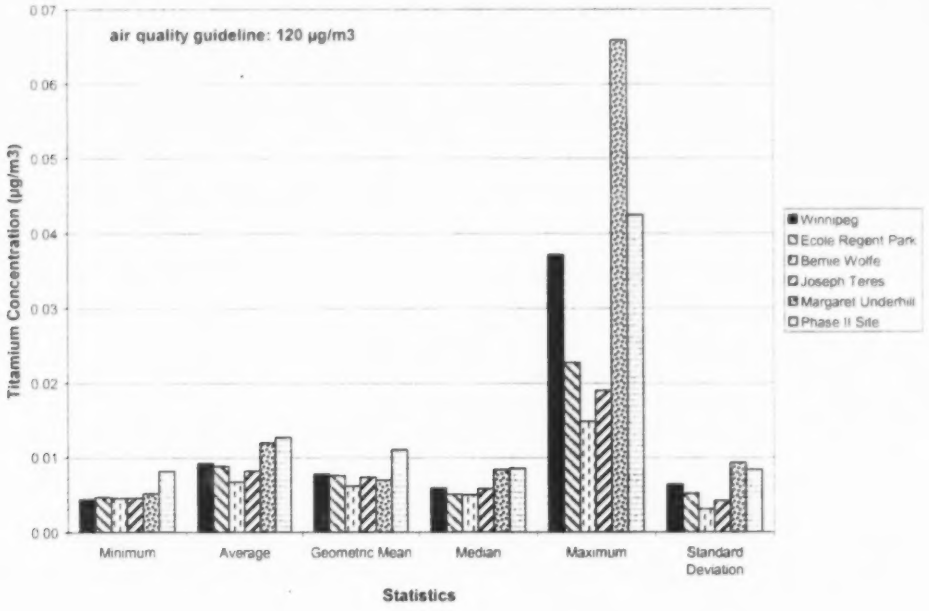


Figure 31. Phase I and Phase II Titanium in $PM_{2.5}$ Concentrations

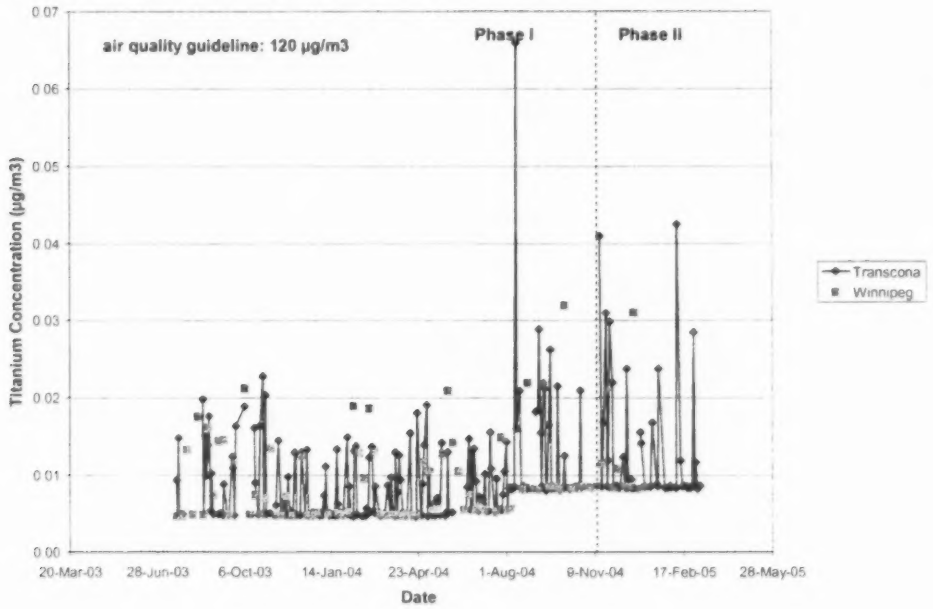


Figure 32. Phase I and Phase II Comparison of Titanium in PM_{10} Concentrations

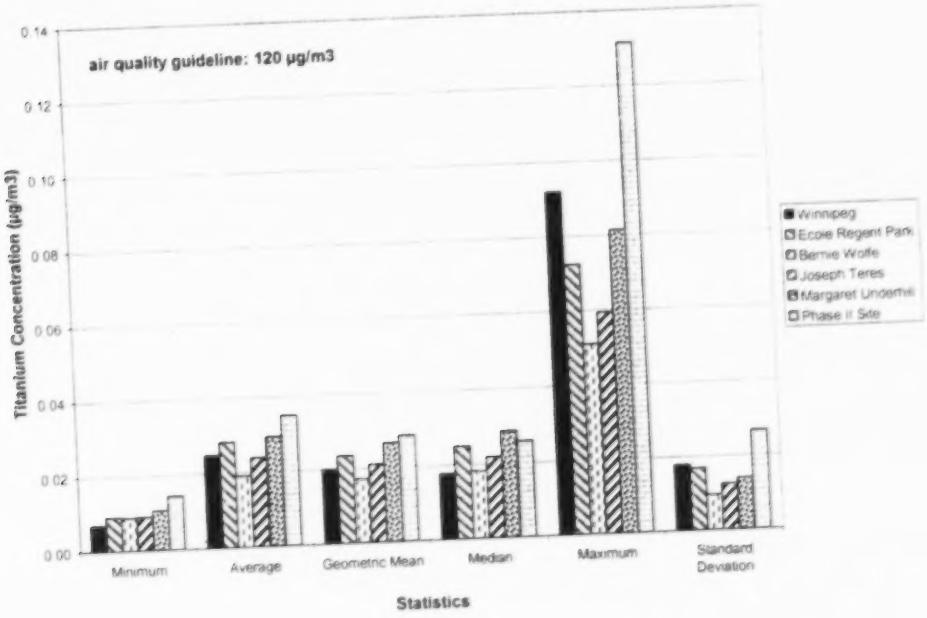
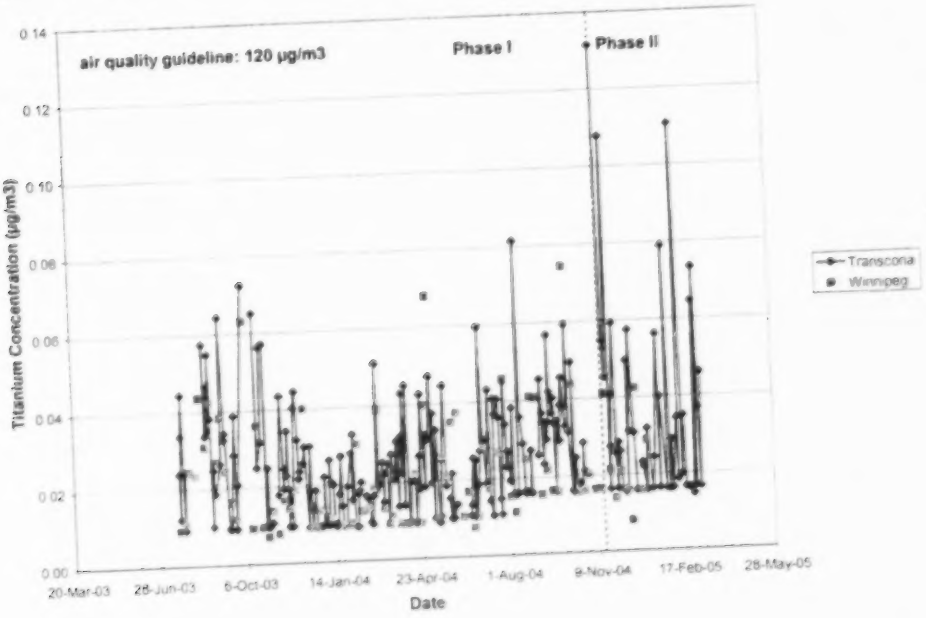


Figure 33. Phase I and Phase II Titanium in PM_{10} Concentrations



2. Other Metals

The seven other metals assessed in both the $PM_{2.5}$ and PM_{10} fractions were: aluminium, antimony, chromium, copper, lead, manganese, and nickel. These metal species were listed in Table 2 as potential air pollutants emitted by sources in the Transcona area. The comparison of the concentrations of the metals at the four Phase I and one Phase II monitoring sites are summarized in Figures 34 to 47.

The measured concentrations of the metal species, in both particulate size fractions ($PM_{2.5}$ and PM_{10}), were substantially less than their respective air quality guidelines. The maximum metal concentrations were less than 4% of their guideline.

Concentrations of aluminium, chromium, copper, lead, and nickel were somewhat higher at the downtown Winnipeg monitoring site than at any of the five Transcona sites. At the École Margaret Underhill monitoring site, antimony, chromium, lead, and nickel tended to be somewhat higher than at the other Transcona monitoring sites. At the Phase II monitoring site, the maximum concentration for each metal was lower than the highest concentration measured for that metal over the entire Phase I monitoring period.

Figure 34. Phase I and Phase II Comparison of Aluminum in $PM_{2.5}$ Concentrations

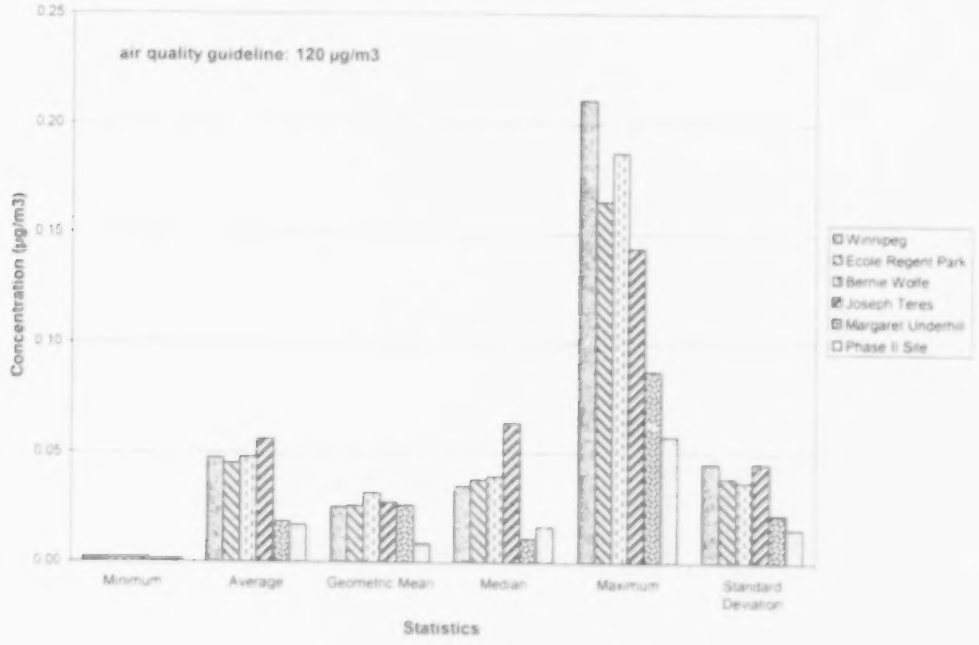


Figure 35. Phase I and Phase II Comparison of Aluminum in PM_{10} Concentrations

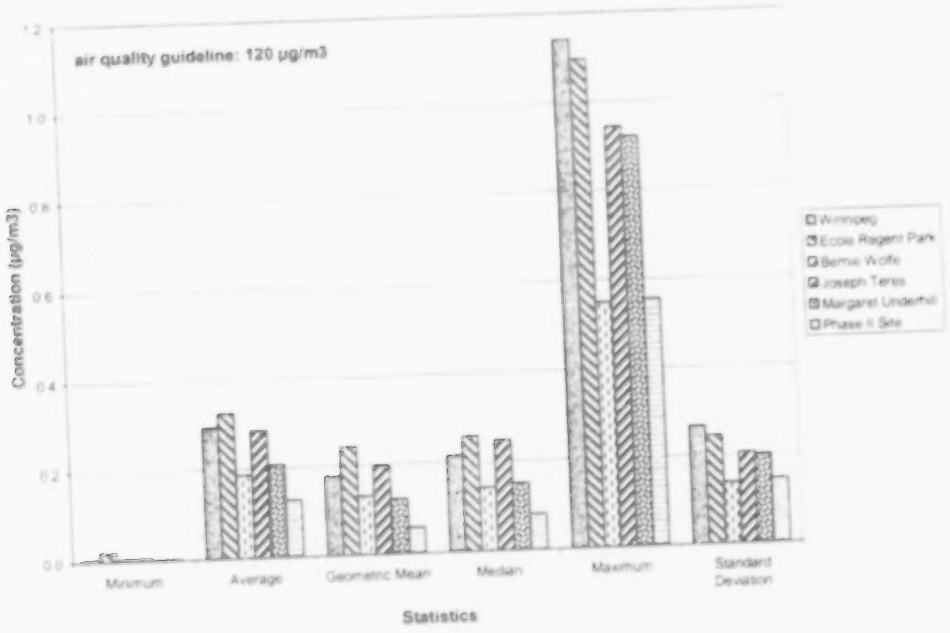


Figure 36. Phase I and Phase II Comparison of Antimony in $PM_{2.5}$ Concentrations

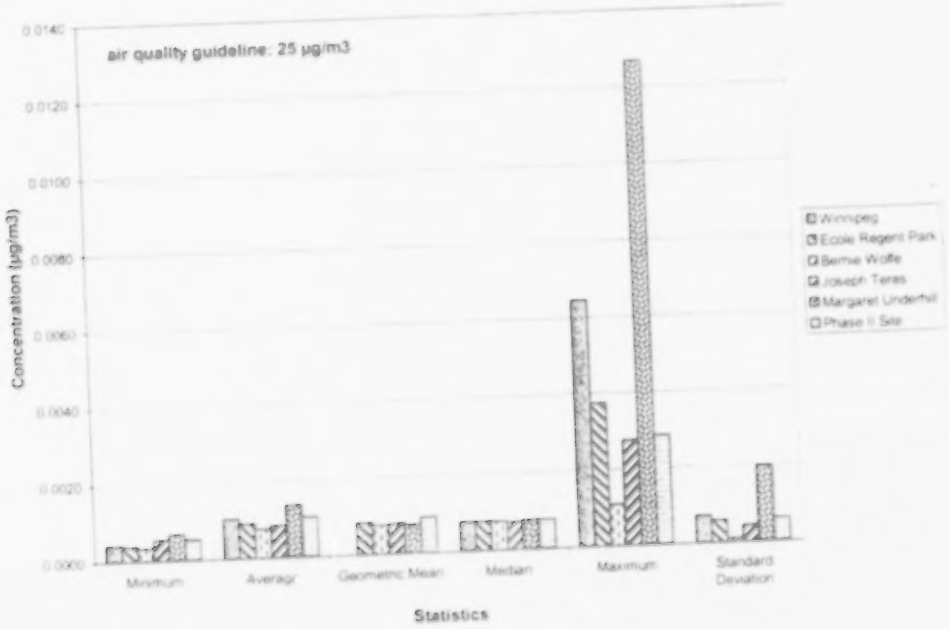


Figure 37. Phase I and Phase II Comparison of Antimony in PM_{10} Concentrations

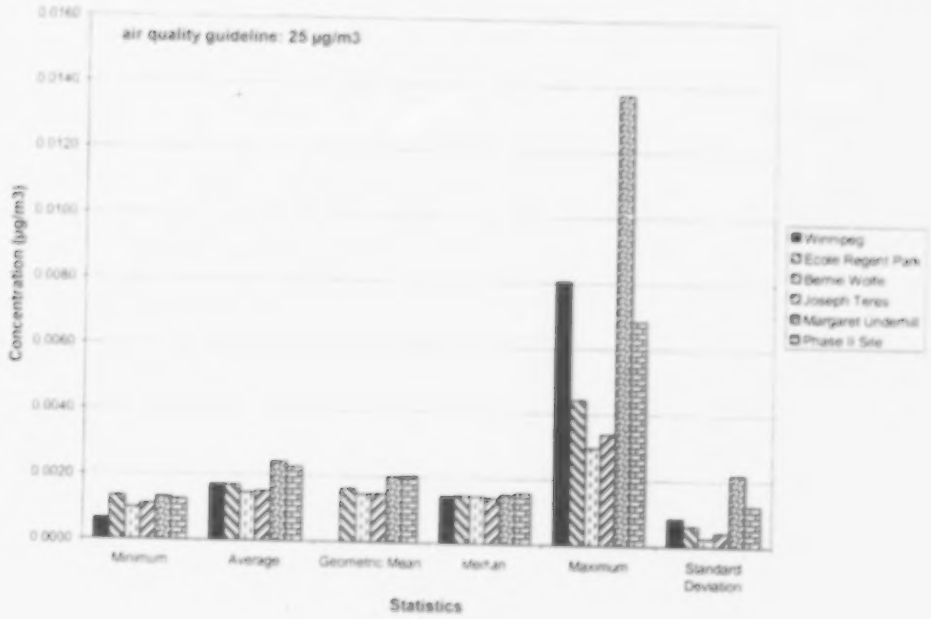


Figure 38. Phase I and Phase II Comparison of Chromium in $PM_{2.5}$ Concentrations

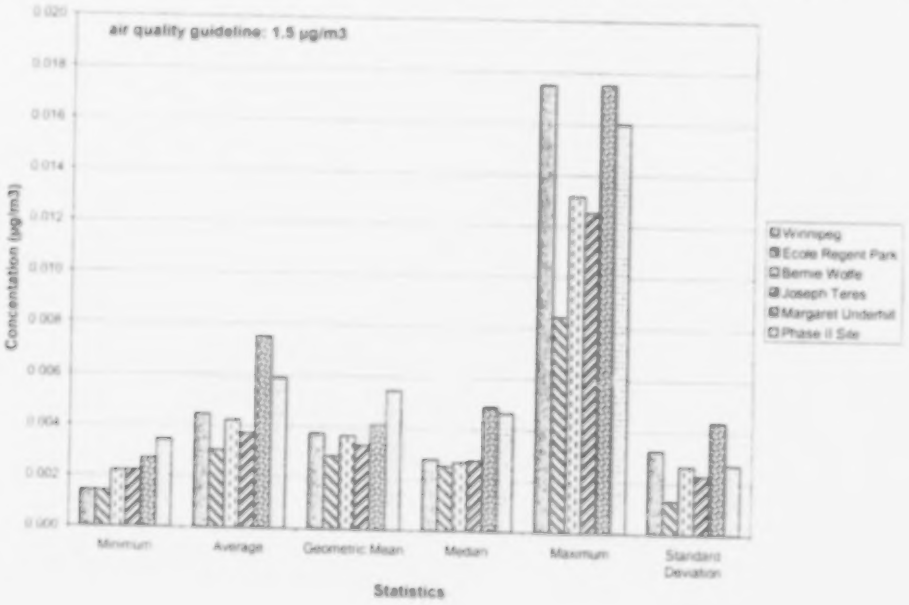


Figure 39. Phase I and Phase II Comparison of Chromium in PM_{10} Concentrations

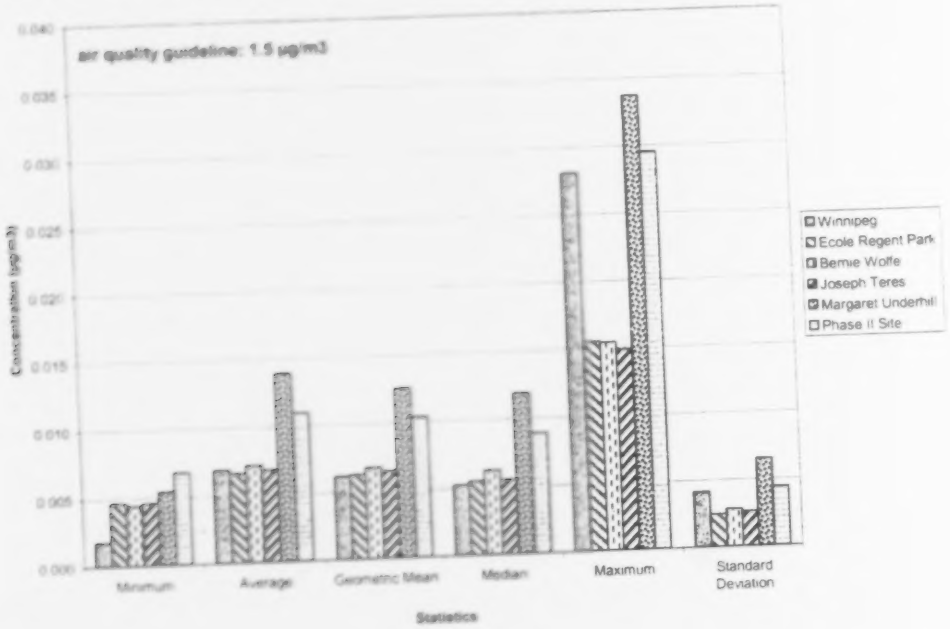


Figure 40. Phase I and Phase II Comparison of Copper in $PM_{2.5}$ Concentrations

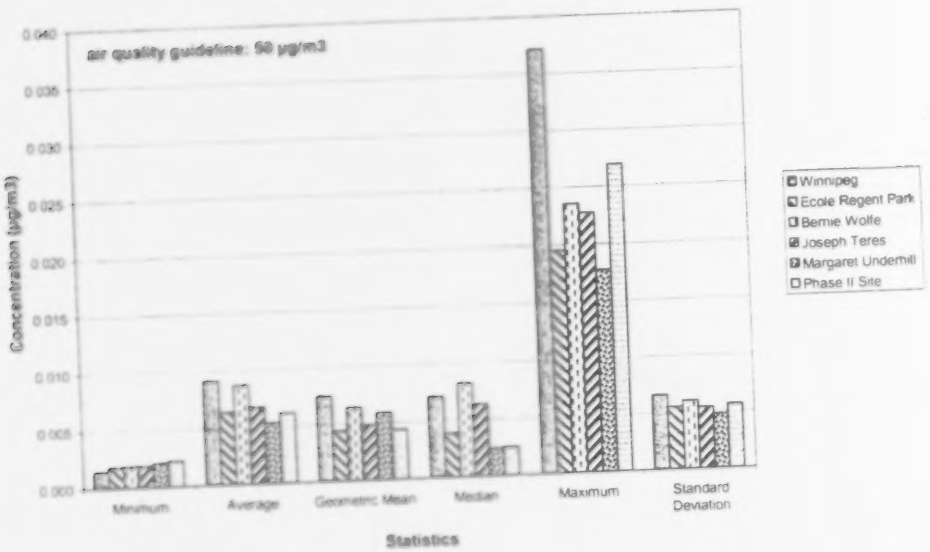


Figure 41. Phase I and Phase II Comparison of Copper in PM_{10} Concentrations

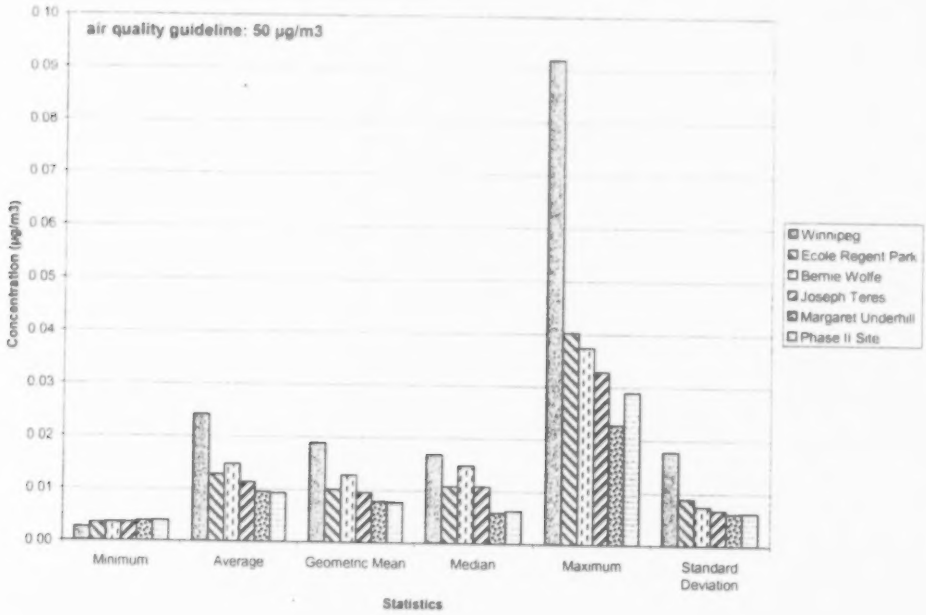


Figure 42. Phase I and Phase II Comparison of Lead in $PM_{2.5}$ Concentrations

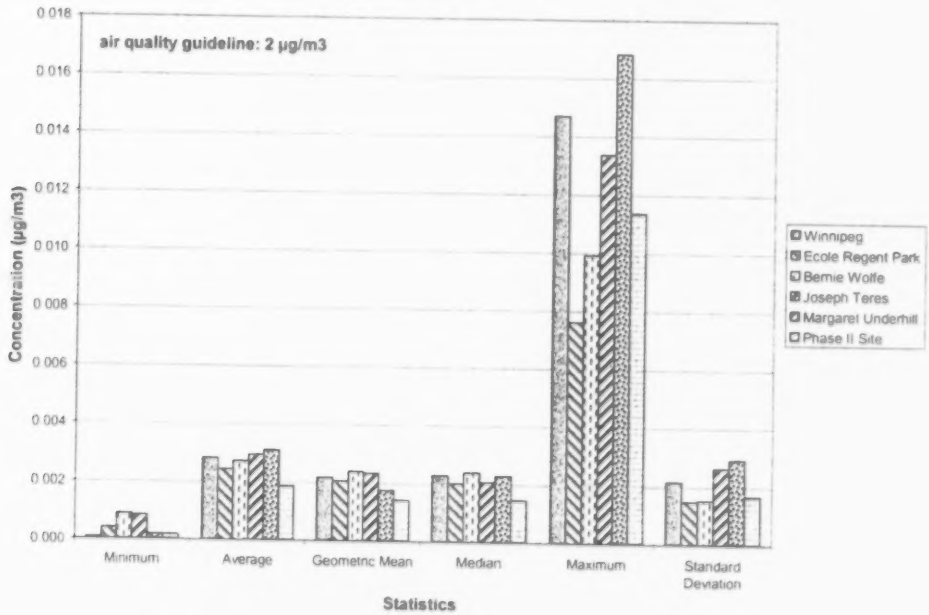


Figure 43. Phase I and Phase II Comparison of Lead in PM_{10} Concentrations

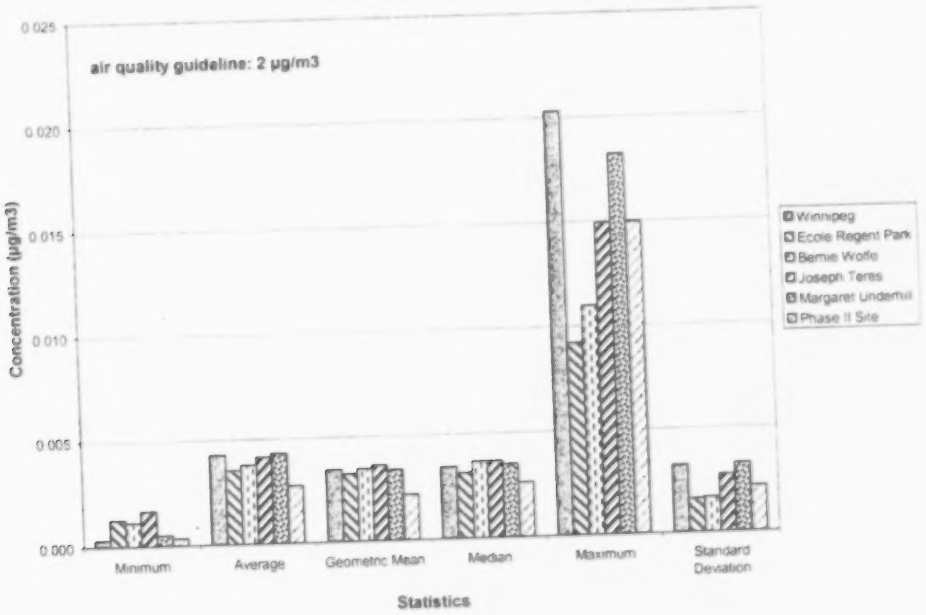


Figure 44. Phase I and Phase II Comparison of Manganese in $PM_{2.5}$ Concentrations

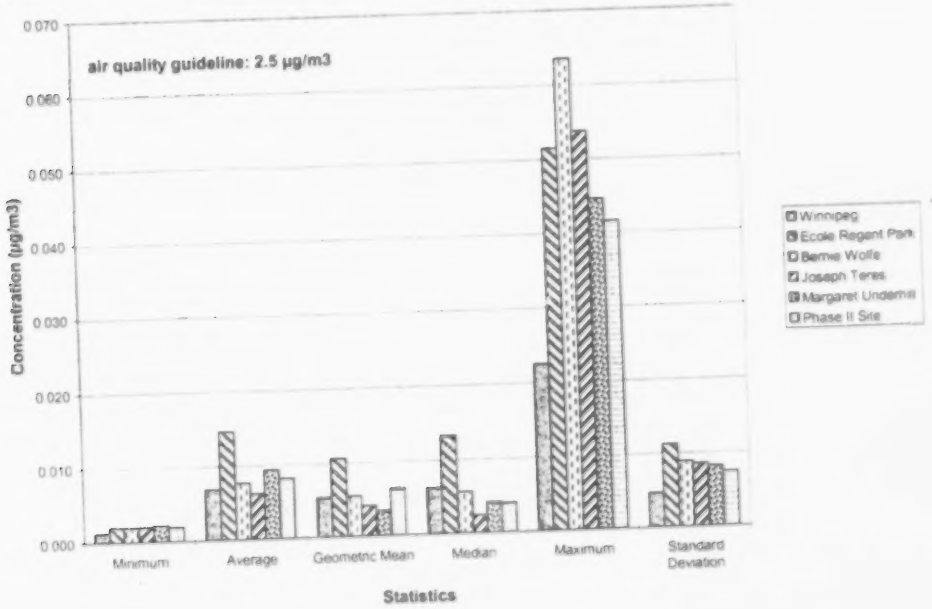


Figure 45. Phase I and Phase II Comparison of Manganese in PM_{10} Concentrations

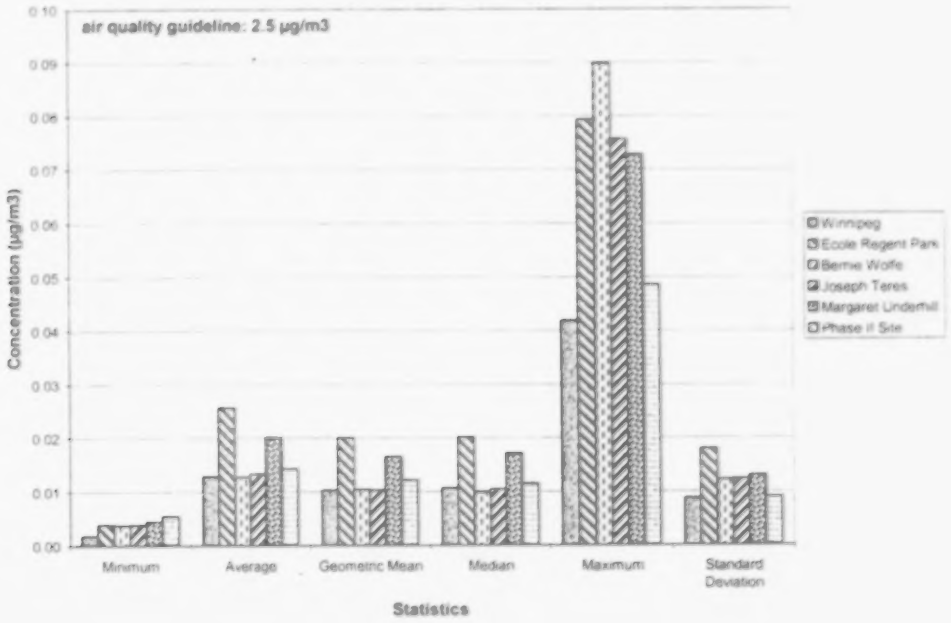


Figure 46. Phase I and Phase II Comparison of Nickel in $PM_{2.5}$ Concentrations

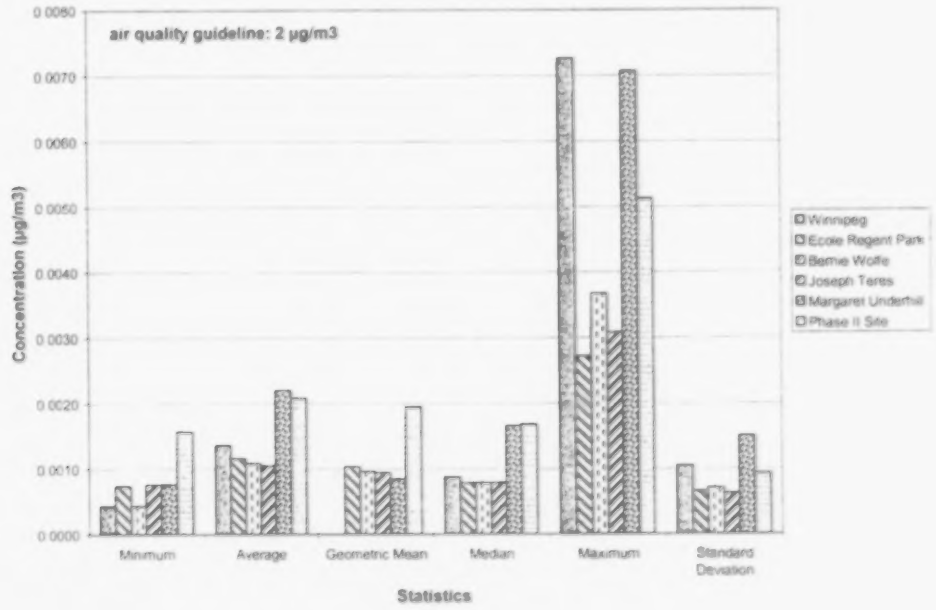
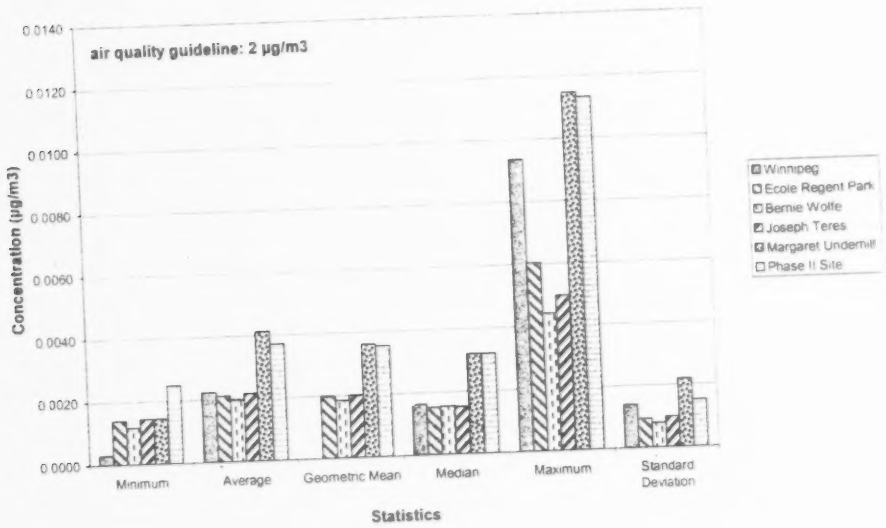


Figure 47. Phase I and Phase II Comparison of Nickel in PM_{10} Concentrations



B. *Volatile Organic Compounds*

The concentrations of eight specific VOC species were assessed for each of the Phase I and Phase II monitoring sites, namely acrolein, benzene, dichloromethane, toluene, xylene, methanol, ethanol, and acetone. Acrolein is a common by-product of combustion, while the other seven VOC species were identified previously in Table 2 as being potentially emitted in the Transcona area.

Data from downtown Winnipeg were also included for comparison, except for methanol and ethanol which are not analyzed at the downtown Winnipeg monitoring sites. These comparisons are shown in Figures 48, 50, 52, 54, 56, 58, 60 and 62. The concentrations of these VOCs were also plotted with time over the entire sampling period in order to identify any high concentrations which may be influencing the results. (See Figures 49, 51, 53, 55, 57, 59, 61 and 63.)

For acrolein, the concentrations (average, median and maximum) were comparable with slightly lower levels being measured in downtown Winnipeg[34], but all were less than 2 $\mu g/m^3$, except for the maximum concentration at École Regent Park on October 15, 2003 (*i.e.*, 34 $\mu g/m^3$) when the guideline of 23.3 $\mu g/m^3$ was exceeded. The source of the elevated acrolein concentration could not be identified. Only 11 of the 197 VOCs had their maximum concentrations of the monitoring period on this date. The next highest acrolein concentration at École Regent Park was 3.0 $\mu g/m^3$ on December 5, 2003.

The available short-term air quality criteria for acrolein vary widely, from 0.19 $\mu g/m^3$ in California to 80 $\mu g/m^3$ in North Carolina. Recently (June 2005), Ontario adopted more

[34] The higher acrolein concentrations in Transcona may be due to differences in the methods used to analyze the downtown Winnipeg and the Transcona data. (Personal communication with T. Dann, Environment Canada on June 12, 2006.)

stringent criteria for acrolein: 0.24 $\mu g/m^3$ (half-hour average) and 0.08 $\mu g/m^3$ (24-hour average). The new half-hour criterion is nearly 100 times more stringent than the previous 1-hour criterion of 23.3 $\mu g/m^3$. When compared with the newer, more stringent Ontario criteria, more elevated levels would be identified in Transcona, similar to other urban areas in Canada including downtown Winnipeg.

The average and median concentrations of benzene, toluene, and acetone were similar among all the monitoring sites; however, these VOCs all had their peak concentration on November 16, 2004 at the Phase II site (36% of the VOCs had their peak concentrations of the entire monitoring period on this date). The maximum concentrations of toluene and acetone, however, were all less than their respective air quality criteria[35].

The benzene concentrations at the Transcona air quality monitoring sites were within the range of benzene levels measured in 18 cities across Canada.[36] The annual average benzene concentration in these 18 cities ranged from 0.6 $\mu g/m^3$ to 5.5 $\mu g/m^3$. At the five Transcona monitoring sites, the average benzene concentration ranged from 0.37 $\mu g/m^3$ at Joseph Teres School to 1.20 $\mu g/m^3$ at the Phase II monitoring site. In comparison, the average benzene level at the downtown Winnipeg monitoring station was 0.95 $\mu g/m^3$.

The dichloromethane average and median concentrations were similar across the sites, while the maximum concentrations varied more significantly. Maximum dichloromethane concentrations were highest at Bernie Wolfe School and the Phase II site and lowest at Joseph Teres School and École Margaret Underhill after the unusually high concentration at École Margaret Underhill had been removed (*i.e.*, 1,866 $\mu g/m^3$ on October 7, 2004). Except for the one École Margaret Underhill sample, all of the dichloromethane concentrations were less than the air quality guideline of 220 $\mu g/m^3$.

Xylene, methanol and ethanol average and median concentrations were similar across the sites, while the maximum concentrations varied more widely with no one site always having the highest concentration. The concentrations of xylene, methanol and ethanol were all less than their respective air quality criteria. The maximum xylene concentrations were highest at downtown Winnipeg, École Regent Park and the Phase II site. The maximum methanol concentration was highest at École Margaret Underhill (October 7, 2004) and similar in value at the other four monitoring sites. The highest ethanol concentrations occurred at École Regent Park, Margaret Underhill School and the Phase II site.

Based on this subset of 8 VOCs from the 197 sampled in the Transcona Phase I and II sampling program, the average and median concentrations of VOCs seem to be comparable between downtown Winnipeg and the five Transcona monitoring sites. The maximum concentrations can vary significantly between the sites with no readily apparent trend; except for dichloromethane and acrolein, the maximum concentrations were less than their respective air quality criteria. The maximum concentrations were occurring at different sites, depending on the chemical species being assessed. There may also be seasonal effects on the data, since the Transcona monitoring sites were sampled at different times of the year.

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[35] Benzene has no air quality guideline.

[36] Analysis and Air Quality Division, Environment Canada, August 2004. *Ambient Air Benzene 2003 Update*. www.ccme.ca assets pdf ambient_air_benzene03.pdf.

Figure 48. Phase I and Phase II Comparison of Acrolein Concentrations

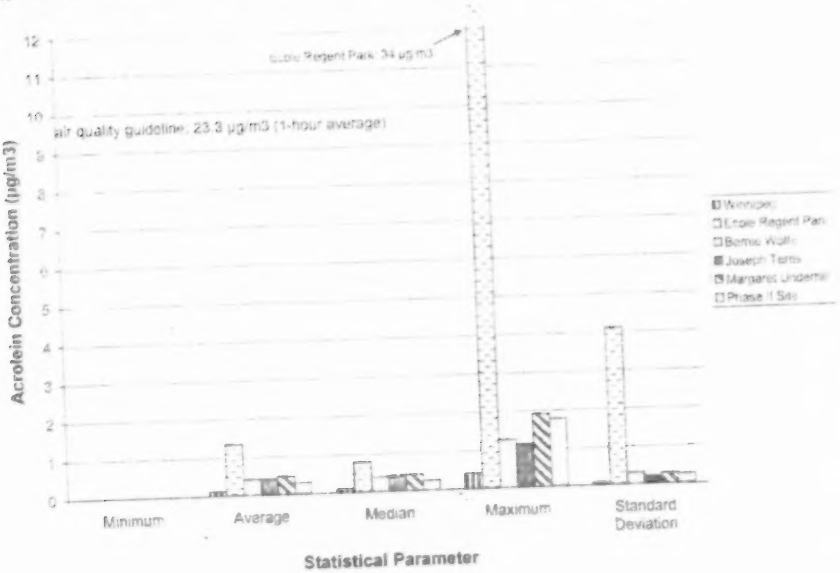


Figure 49. Phase I and Phase II Acrolein Concentrations

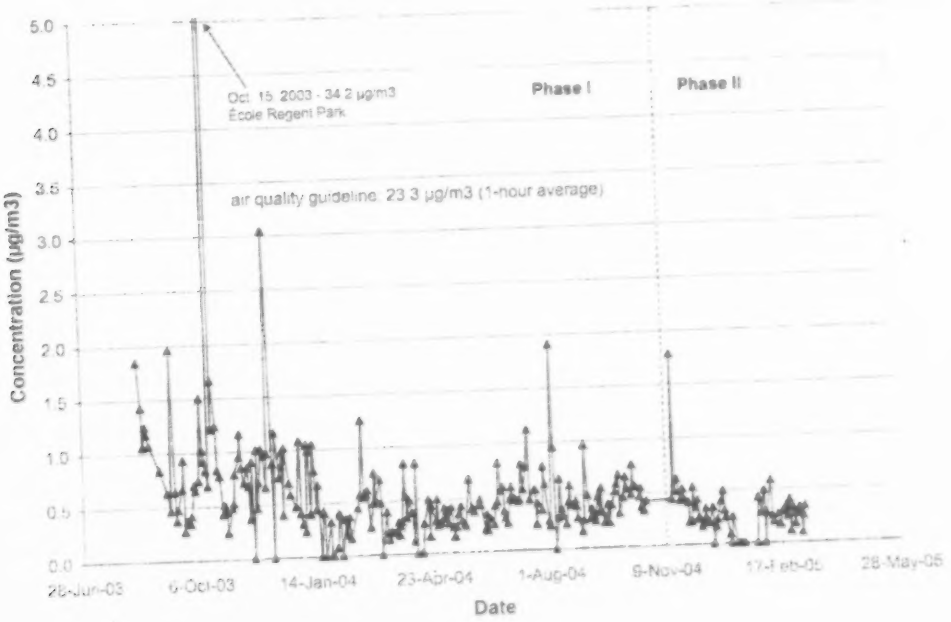


Figure 50. Phase I and Phase II Comparison of Dichloromethane Concentrations

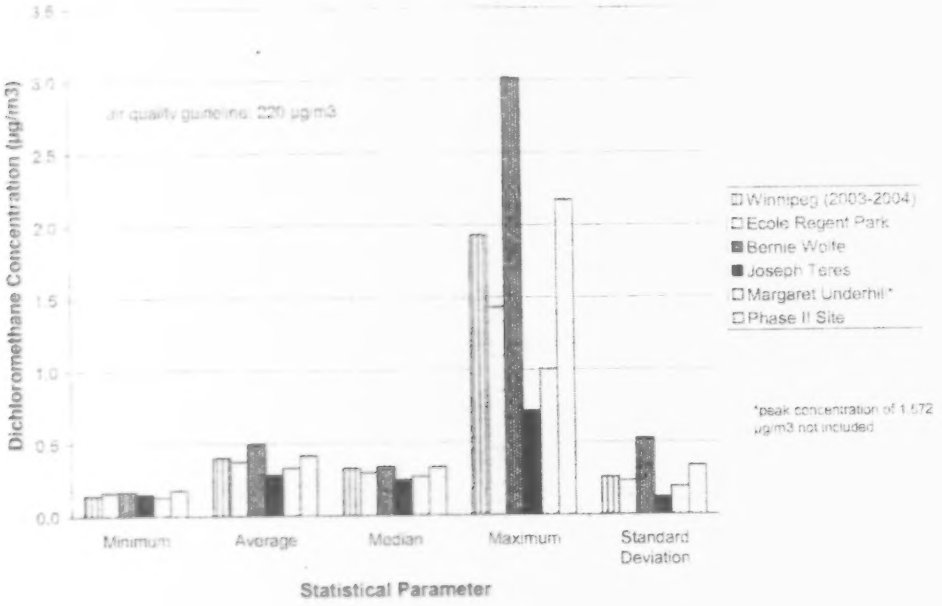


Figure 51. Phase I and Phase II Dichloromethane Concentrations

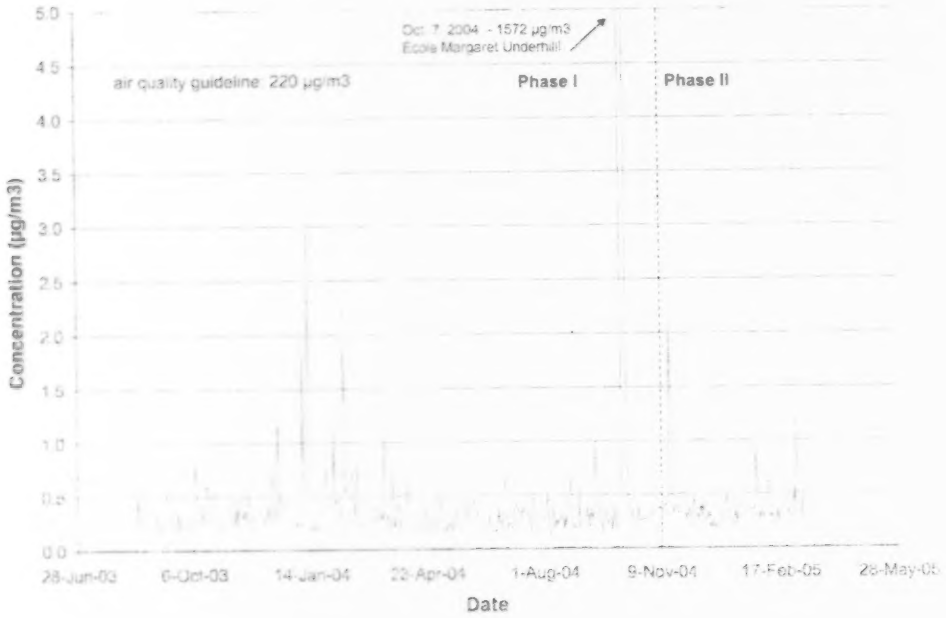


Figure 52. Phase I and Phase II Comparison of Benzene Concentrations

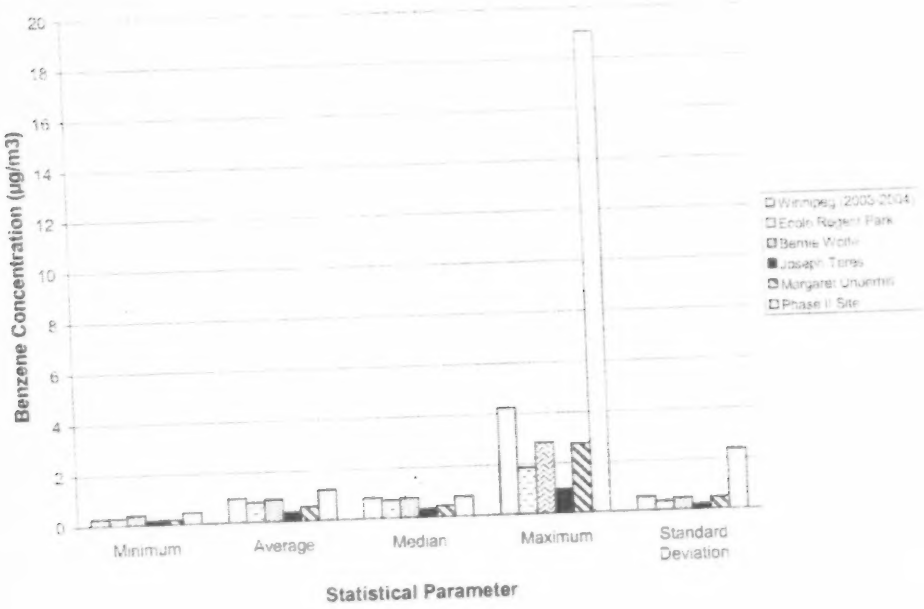


Figure 53. Phase I and Phase II Benzene Concentrations

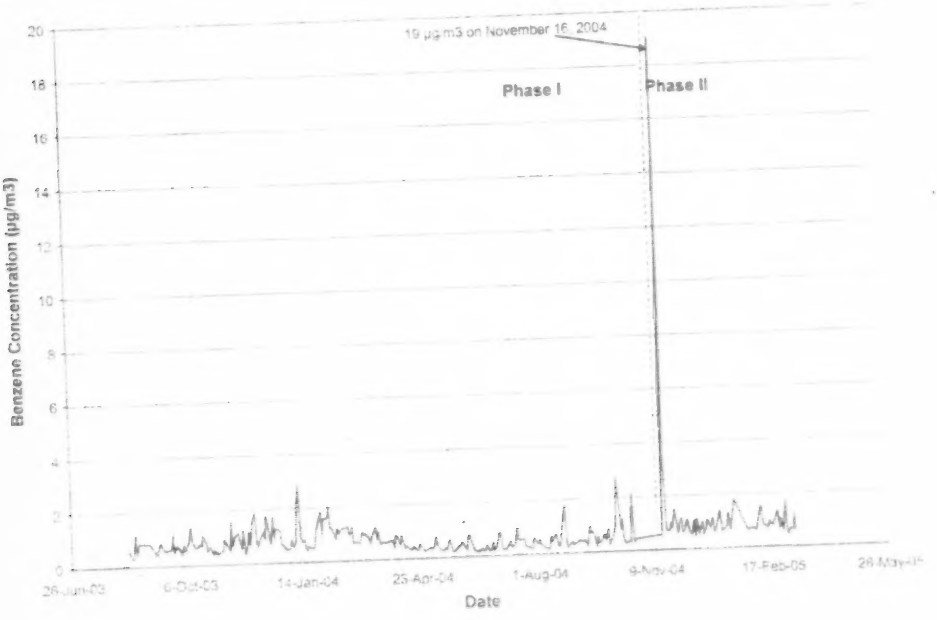


Figure 54. Phase I and Phase II Comparison of Toluene Concentrations

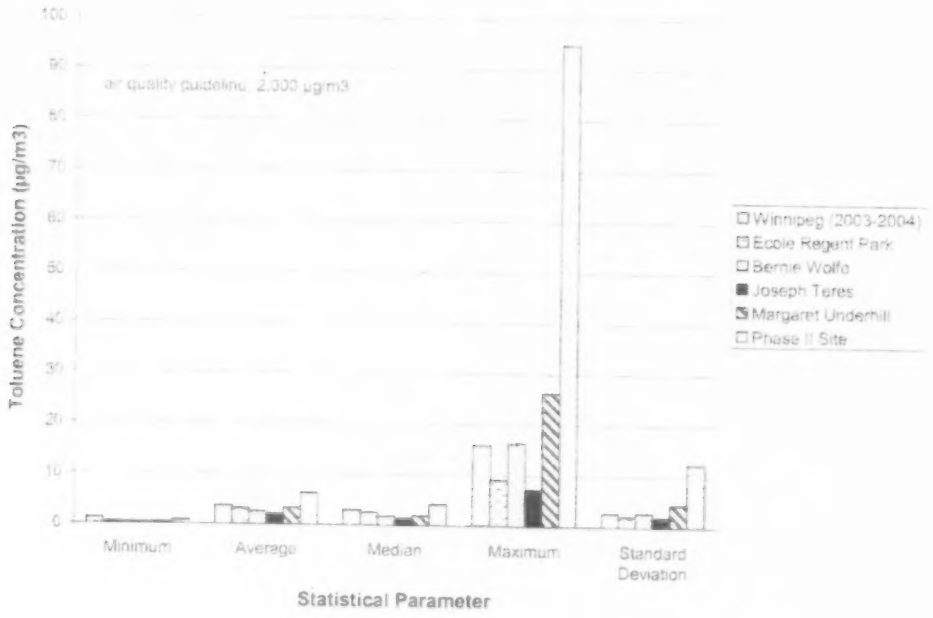


Figure 55. Phase I and Phase II Toluene Concentrations

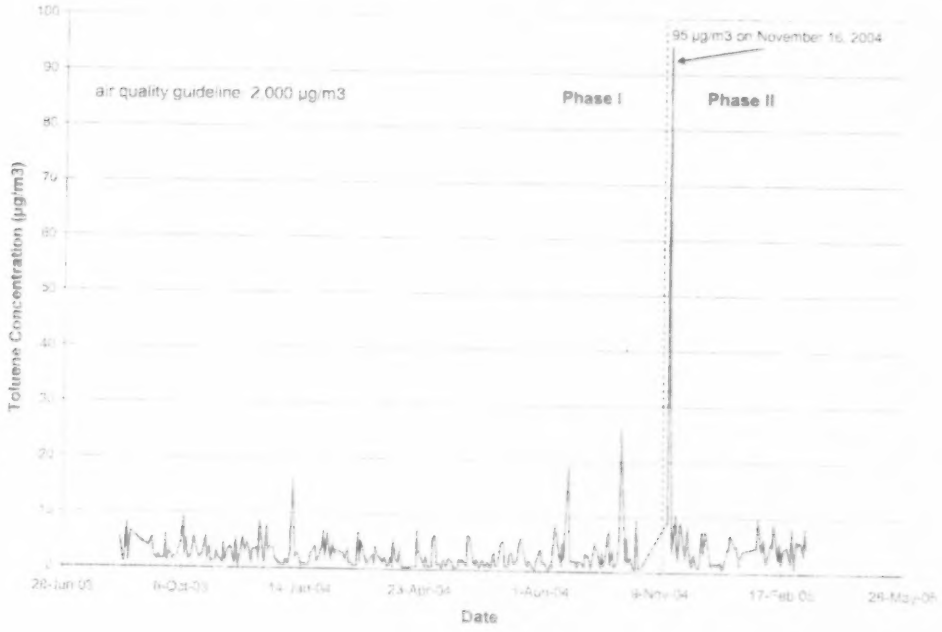


Figure 56. Phase I and Phase II Comparison of Xylene Concentrations

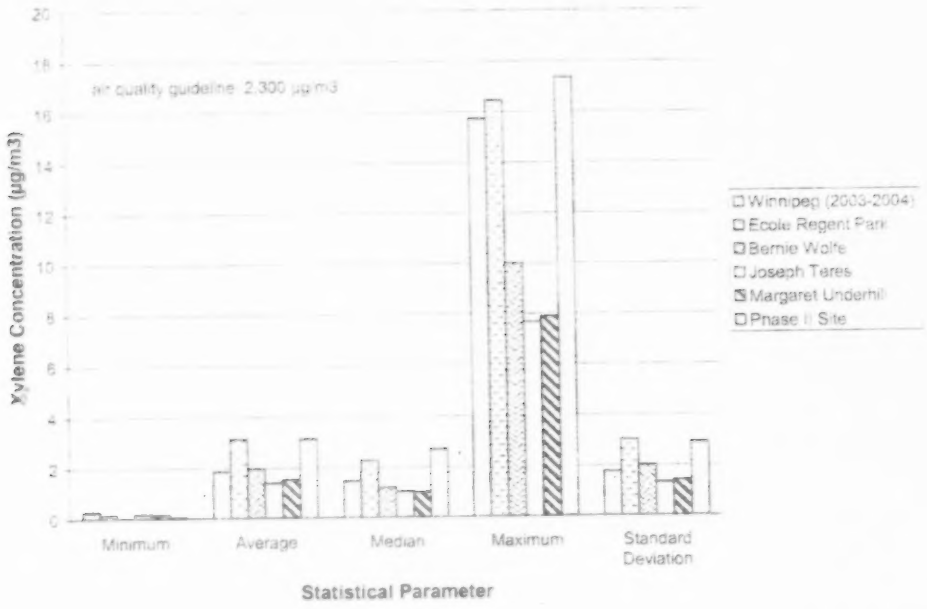


Figure 57. Phase I and Phase II Xylene Concentrations

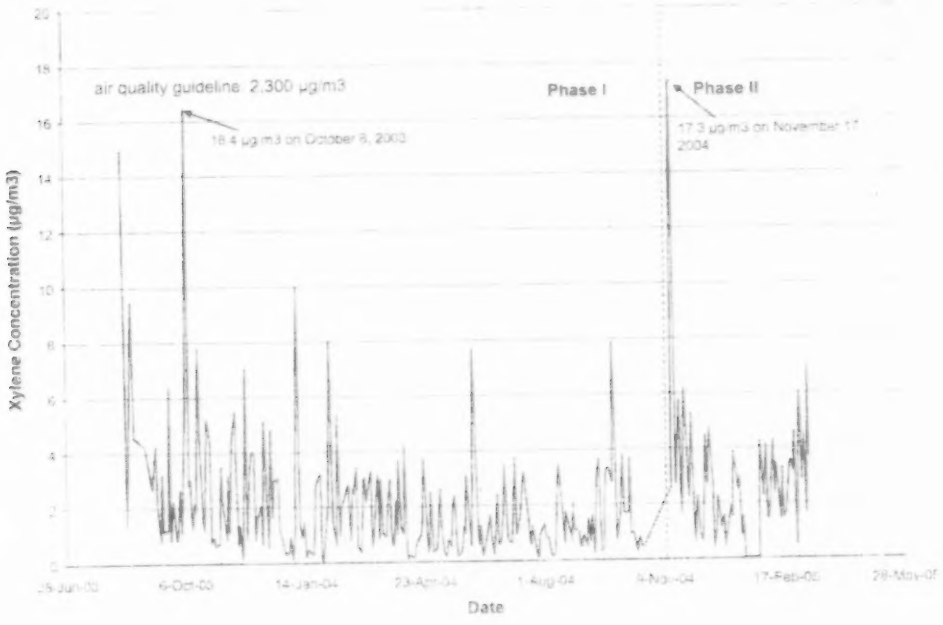


Figure 58. Phase I and Phase II Comparison of Methanol Concentrations

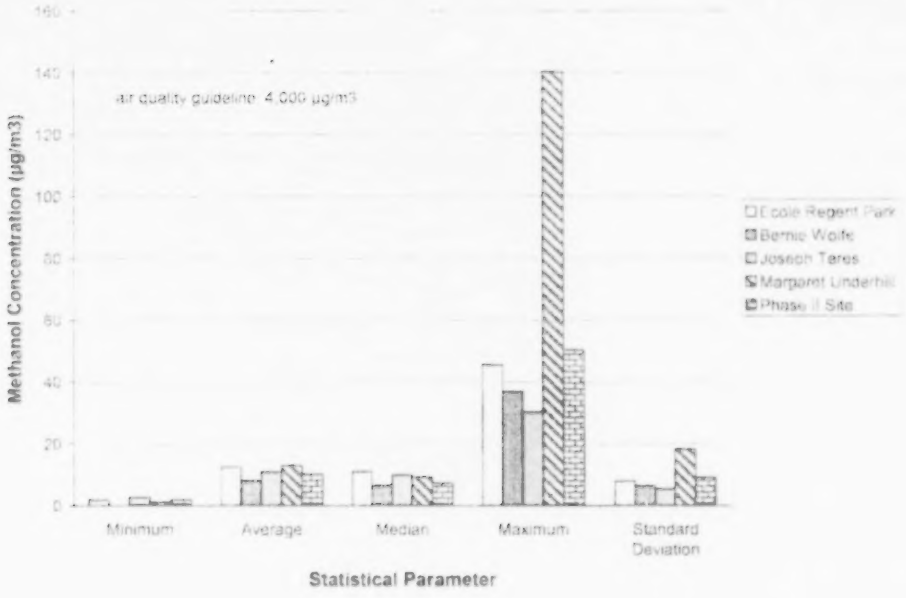


Figure 59. Phase I and Phase II Methanol Concentrations

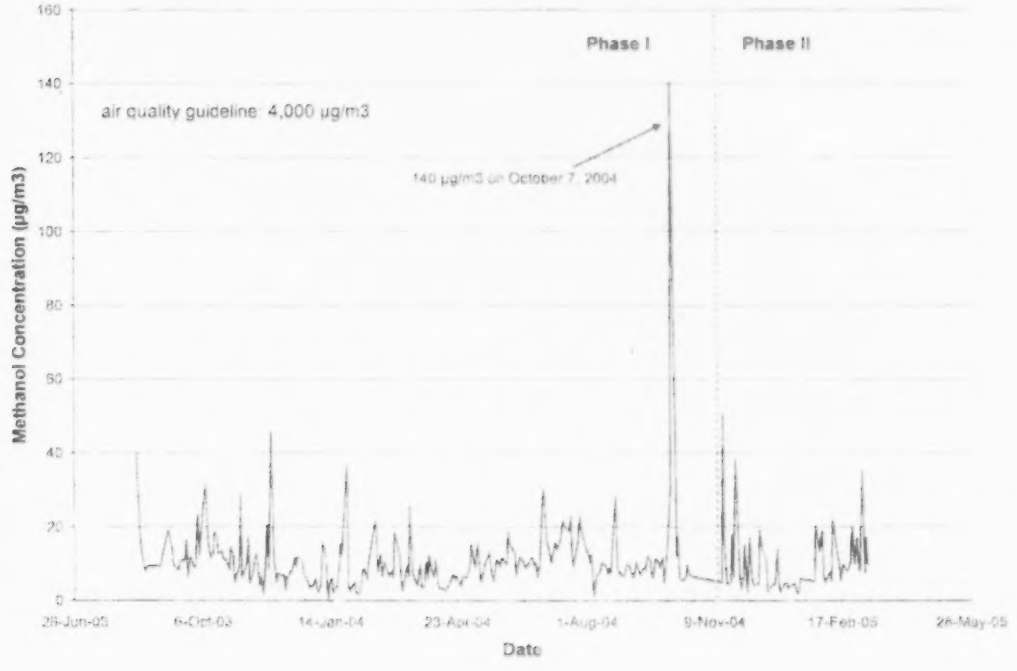


Figure 60. Phase I and Phase II Comparison of Ethanol Concentrations

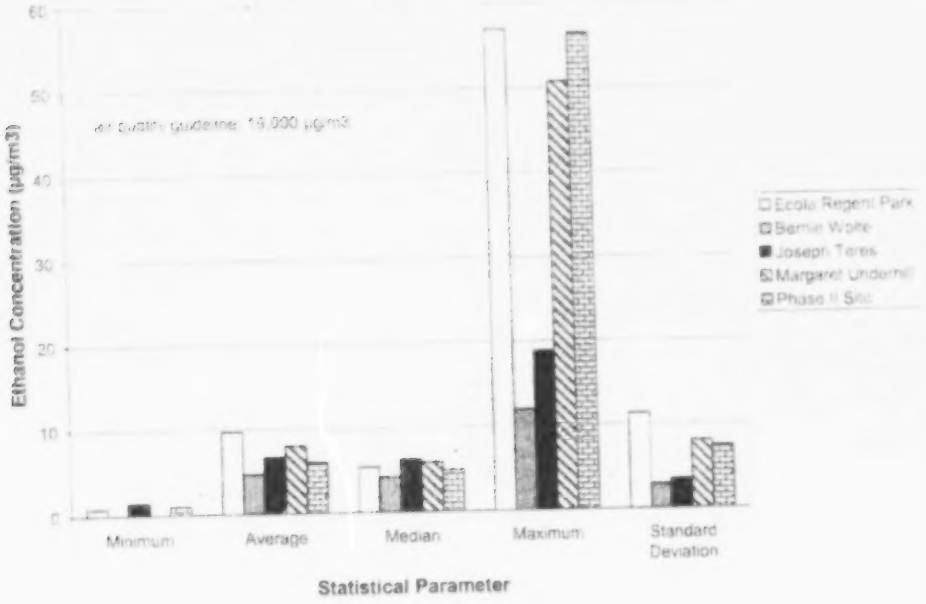


Figure 61. Phase I and Phase II Ethanol Concentrations

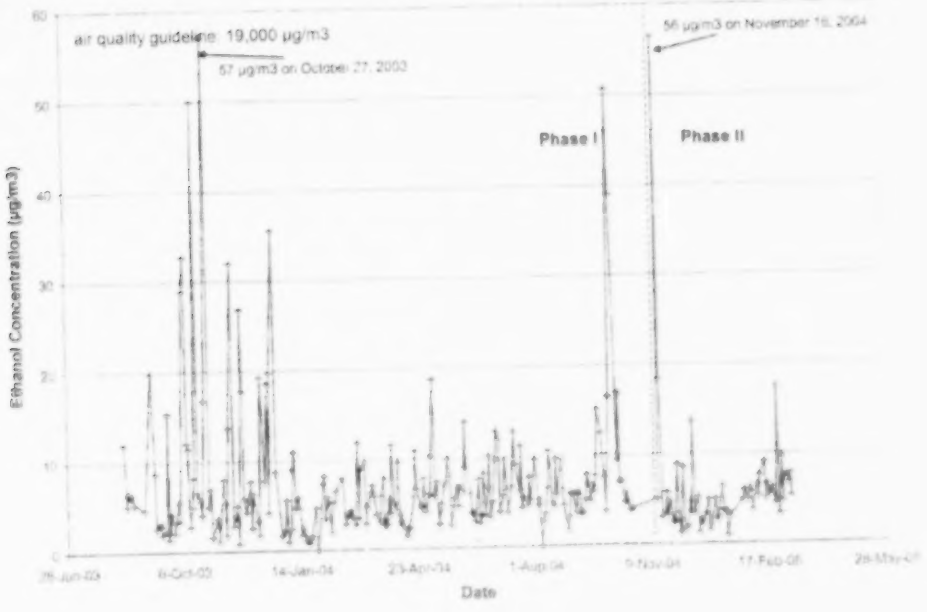


Figure 62. Phase I and Phase II Comparison of Acetone Concentrations

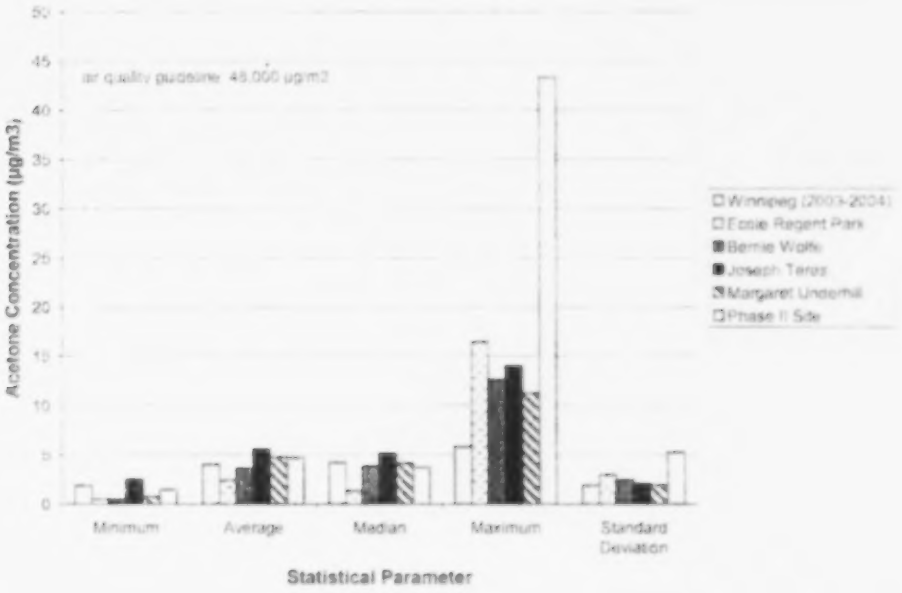
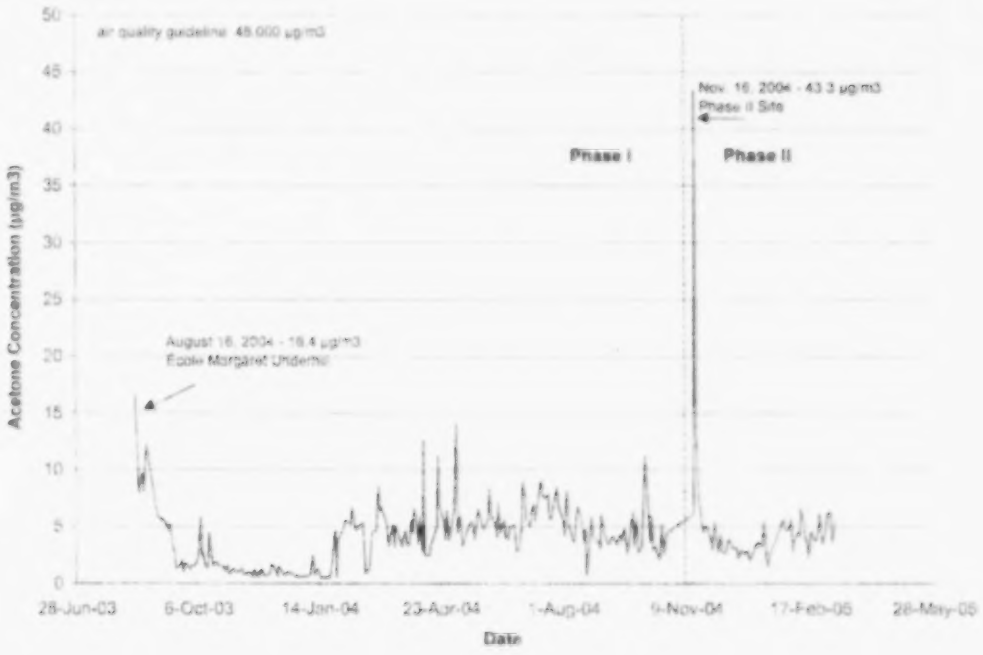


Figure 63. Phase I and Phase II Acetone Concentrations



IV. Summary of Air Quality in the Transcona Area of Winnipeg

Manitoba Conservation undertook Phase I of this air quality monitoring study to address questions about the effects that industrial emissions from companies located in Transcona and adjacent communities might be having on the air quality in the Transcona area. Phase I was designed to provide a perspective on the general air quality in the area due to all local sources rather than to assess the effect of any specific industry. Phase II of this air quality study was undertaken to assess the effect a specific local industrial source of emissions might be having on local air quality. During Phase I and Phase II of this monitoring study, 262 particulate matter and 297 VOC samples were collected for analysis. In total, over 70,800 pieces of data were collected.

1. Phase I (Sampling Period: July 20, 2003 to October 25, 2004):

Phase I of this air quality study indicated that air quality in the Transcona area was good because the concentrations of particulate matter, particulate matter constituents, and VOCs (except for the two exceedances as noted below) were less than their respective air quality guidelines. The air quality in Transcona was quite similar to the air quality observed at other monitoring sites in Winnipeg.

During Phase I, there were no exceedances of Manitoba ambient air quality criteria for particulate matter (PM_{10} and $PM_{2.5}$) or for the specific constituents found in the particulate matter with the constituents being only a small fraction of their respective air quality criteria. Direct comparison of Transcona with other Winnipeg particulate matter concentrations was limited because the data were collected using different monitoring equipment. Data from Transcona were collected using a dichotomous sampler, while most of the other Winnipeg data were collected using a TEOM analyser. TEOM analyzers tend to underestimate particulate concentrations, especially during the colder months.

Except for acrolein and dichloromethane, all other VOCs were within air quality guidelines; usually the VOCs were only a small fraction of the guideline. Acrolein and dichloromethane each exceeded their ambient air quality criteria (23.3$\mu g/m^3$ and 220 $\mu g/m^3$, respectively) only once. A specific cause for the elevated acrolein concentration could not be identified. The unusually high concentration of dichloromethane coupled with the high winds that day would suggest a very localized source of the solvent was responsible for the high concentration. The actual source, however, could not be identified.

2. Phase II (Sampling Period: November 15, 2004 to March 8, 2005):

There was only one monitoring site for Phase II of this air quality monitoring study. This site was located on the roof of a building at 543 Pandora Avenue West (Warren's Corner Sports), in close proximity to New Flyer Industries Inc.. Phase II of this air quality study indicated that air quality in the Transcona area, in proximity to a local source of emissions, was good and was similar to the air quality observed elsewhere in Winnipeg.

During Phase II, there were no exceedances of the Manitoba ambient air quality criteria for particulate matter (PM_{10} and $PM_{2.5}$) or for constituents associated with the particulate matter, with the constituents being only a small fraction of their respective air quality criteria. As in Phase I, it was difficult to compare Transcona and downtown Winnipeg

particulate matter concentrations because the data from Transcona was collected using a dichotomous sampler while the corresponding downtown Winnipeg data was collected using a TEOM analyser. PM_{10} concentrations appeared to be lower in Transcona than in downtown Winnipeg. $PM_{2.5}$ concentrations in Transcona were higher than downtown Winnipeg TEOM levels, but similar to downtown Winnipeg dichotomous levels.

None of the VOC air quality guidelines were exceeded in Phase II; usually the VOCs were only a fraction of the guidelines. The average and median concentrations appeared comparable for a small subset of specific VOCs that was analyzed. The highest levels of this subset varied considerably with no discernable trend among the sites.

In summary, based on the data collected at the Phase II monitoring site, particulate matter and constituents associated with the particulate matter are found in normal and acceptable concentrations in Transcona areas directly in the vicinity of a local source of emissions. Any reduction in air quality is due to the occasional presence of somewhat higher levels of specific VOCs in the air, although the levels were still well below air quality guidelines.

Overall, based on this two-phase monitoring study, the air quality in the Transcona area was found to be good with air quality guidelines only being exceeded on two occasions. All other air pollutant levels were generally very low, typically only a small fraction of the air quality guidelines and similar to air quality found in other areas of Winnipeg.